

EXHIBIT 2

STANDARD SETTING, PATENTS, AND HOLD-UP

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I. STANDARD SETTING, PATENTS, AND HOLD-UP: A TROUBLESOME MIX

Standard setting raises a variety of antitrust issues. Cooperative standard setting often involves horizontal competitors agreeing on certain specifications of the products they plan to market, implicating core antitrust issues regarding the boundary between cooperation and collusion. The American Bar Association's *Handbook on the Antitrust Aspects of Standards Setting* presents legal analysis of many such issues.¹ Shapiro and Varian discuss business strategy in standard setting, and Shapiro addresses the boundary between cooperative standard setting and collusion.²

This article focuses on a problem that the ABA *Handbook* labels "patent ambush"³ and that economists call "opportunism" or "hold-up." In very broad terms, opportunism or hold-up arises when a gap between economic commitments and subsequent commercial negotiations enables one party to capture part of the fruits of another's investment,

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¹ ABA SECTION OF ANTITRUST LAW, HANDBOOK ON THE ANTITRUST ASPECTS OF STANDARDS-SETTING chs. 15–17 (2004) [hereinafter ABA STANDARDS-SETTING HANDBOOK].

² CARL SHAPIRO & HAL R. VARIAN, INFORMATION RULES: A STRATEGIC GUIDE TO THE NETWORK ECONOMY ch.9 (1999); Carl Shapiro, *Setting Compatibility Standards: Cooperation or Collusion?*, in EXPANDING THE BOUNDARIES OF INTELLECTUAL PROPERTY 91–93 (Rochelle Dreyfuss et al. eds., 2001).

³ See ABA STANDARDS-SETTING HANDBOOK, *supra* note 1, at 60–64.

broadly construed. Hold-up can arise, in particular, when one party makes investments specific to a relationship before all the terms and conditions of the relationship are agreed. Hold-up generally leads to economic inefficiency that contracting parties, and courts interpreting contracts, often try to avoid.⁴ "Bad" behavior (such as deception) is not logically necessary for such inefficiency, but hold-up can powerfully reward deception and concealment. Emphasizing how parties may inefficiently seek hold-up power, Oliver Williamson famously described opportunism as "self-interest seeking with guile."⁵

We discuss the risk of hold-up when standard-setting organizations (SSOs) include patented technology in standards. We focus on the mechanism of, and techniques for avoiding, inefficient patent hold-up. The pure economics are largely unaffected by whether or not guile is involved, but of course policy and legal treatment may be strongly affected. With this in mind, we offer some reflections on the application of antitrust principles to patent hold-up in standards, but stress that while the economics are relatively clear-cut, difficult issues of enforcement arise.

We begin with a review of cases concerning opportunism in SSOs. Ten years ago, the Federal Trade Commission alleged that Dell Computer had affirmed to the Video Electronics Standards Association (VESA) that Dell had no patent rights on VESA's proposed VL-bus standard, but, after adoption of the standard, Dell asserted its patent.⁶ The Commission found that VESA's strong preference for standards that did not include proprietary technology provided "evidence that the association would have implemented a different non-proprietary design" had Dell disclosed the patent.⁷ Dell entered into a settlement agreement prohibiting it from enforcing its VL-bus patent against any company using the standard and restricting it from enforcing any patent included in a standard if Dell intentionally failed to disclose the patent upon an SSO's written request.⁸

In memory module design, Wang Laboratories encouraged a subcommittee of the Joint Electron Device Engineering Council (JEDEC) to adopt a standard on which Wang had pending patent applications.

⁴ *Broadcom Corp. v. Qualcomm Inc.*, 501 F.3d 297, 310–14 (3d Cir. 2007).

⁵ OLIVER WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM: FIRMS, MARKETS, RELATIONAL CONTRACTING 47 (1985).

⁶ *Dell Computer Corp.*, 121 F.T.C. 616, 618 (1996) (Complaint, Decision, and Order) [hereinafter *Dell Complaint, Decision, and Order*], available at <http://www.ftc.gov/os/1999/08/9823563c3888dell.htm>.

⁷ *Id.* at 623.

⁸ *Id.* at 620–21, §§ 2–4.

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Before lobbying JEDEC to adopt the design and before applying for patents, Wang had stated that it was not seeking patent rights on the design. Even after applying for the patents, Wang did not disclose to JEDEC that it had done so. After the patents issued, Wang sought to assert them, but was found, through its conduct, to have granted an implied license to Mitsubishi.⁹

More recently, the FTC found Rambus guilty of monopolization for similar conduct,¹⁰ and there have been private actions concerning essentially the same conduct.¹¹ While a member of JEDEC, Rambus "sat silently" when technologies were adopted that eventually became subject to Rambus's patent claims; voted on the inclusion of other technologies "without revealing that it was seeking patent coverage of those technologies"; evaded questions about its patent portfolio; and provided a list of its patents that excluded the one it believed applied to the proposed JEDEC standard.¹² The Commission found that these deceptive actions, in the context of "an express duty of good faith"¹³ arising from JEDEC's policies and practices, "contributed significantly to Rambus's acquisition of monopoly power . . ."¹⁴ and constituted monopolization.¹⁵ Its remedy constrains Rambus's royalties.¹⁶

While we focus primarily on such deception or failure to disclose patents, a similar economic logic underlies some cases where patents were disclosed but users assert that the patent holder is not meeting its duty to license in a reasonable fashion. For example, 3GPP, which sets standards in wireless communications technology, adopted the UMTS standard, which marks a transition from the GSM technology used in 2G mobile telephony to the WCDMA technology used in 3G mobile teleph-

⁹ Wang Labs., Inc. v. Mitsubishi Elecs. Am. Inc., 163 F.3d 1571, 1582 (Fed. Cir. 1997). Author Joseph Farrell was retained by Mitsubishi in this litigation.

¹⁰ Rambus Inc., FTC Docket No. 9302, Opinion of the Commission § (Aug. 2, 2006), available at <http://www.ftc.gov/os/adjpro/d9302/060802commissionopinion.pdf> [hereinafter *Rambus Inc., Opinion of the Commission*], appeal pending (D.C. Cir.).

¹¹ *Id.* at 66. Other Rambus cases include Hynix Semiconductor Inc. v. Rambus Inc., No. CV-00-20905, 2006 U.S. Dist. LEXIS 63140 (N.D. Cal. Aug. 22, 2006); Micron Tech. Inc. v. Rambus Inc., No. 00-792, 2006 U.S. Dist. LEXIS 40099 (D. Del. June 15, 2006); and Rambus Inc. v. Infineon Techs. AG, 155 F. Supp. 2d 668 (E.D.Va. 2001). Author Joseph Farrell was briefly a consultant to FTC Staff and later was retained by Hynix in connection with its private case against Rambus; authors Hayes and Sullivan were also retained by Hynix in that litigation.

¹² *Rambus Inc., Opinion of the Commission*, *supra* note 10, at 66.

¹³ *Id.*

¹⁴ *Id.* at 68.

¹⁵ *Id.* at 27–115, 118.

¹⁶ Opinion of the Commission on Remedy § III.C, *Rambus Inc., FTC Docket No. 9302* (Feb. 5, 2007) [hereinafter *Rambus Inc., Remedy Opinion*], available at <http://www.ftc.gov/os/adjpro/d9302/070205opinion.pdf>.

ony.¹⁷ Broadcom and others allege that the royalties Qualcomm now demands for its essential UMTS patents violate the promise Qualcomm made when the standard was under development to license its patents on fair, reasonable, and non-discriminatory (FRAND) terms.¹⁸ As discussed below, these aspects of Broadcom's complaint were dismissed, but that decision was reversed on appeal and the case was remanded.¹⁹ Townshend and co-defendant 3Com were alleged to have lobbied the International Telecommunications Union (ITU) to adopt the V.90 modem standard incorporating Townshend's patented technology and then to have demanded royalties that violated the ITU's patent policy.²⁰ Similar claims were brought by Rockwell against Motorola in the earlier V.34 modem standard.²¹

¹⁷ See, e.g., UMTSWorld.com, The History of UMTS and 3G Development, <http://www.umtsworld.com/umts/history.htm>. 3GPP refers to the Third Generation Partnership Project, an SSO specific to wireless technologies. UMTS is the Universal Mobile Telephone System, a leading third-generation (3G) mobile wireless technology. GSM is the Global System for Mobile communications, a leading second generation (2G) mobile wireless technology. Wideband Code Division Multiple Access (WCDMA) is the radio access network used in UMTS. Time Division Multiple Access (TDMA) is the radio access network used in GSM. UMTS FORUM at 20, *Mobile Evolution: Shaping the Future*, Jan. 8, 2003, available at http://www.umts-forum.org/component?option=com_docman&task=cat_view&gid=827&Itemid=12/.

¹⁸ First Amended Complaint at 2, *Broadcom Corp. v. Qualcomm Inc.*, C.A. No. 05-3350 (D.N.J. 2005) [hereinafter *Broadcom Complaint*], LEXSEE 2005 U.S. Dist. Ct. Pleadings 3350A. Nokia is also in litigation with Qualcomm over related claims in Europe and the United States. See, e.g., Complaint, In the Matter of Certain Mobile Telephone Handsets, Wireless Communication Devices, and Components Thereof, Investigation No. 337-TA-2492 (June 9, 2006). In addition, several wireless companies have lodged a complaint against Qualcomm with the European Commission. See Kevin Fitchard, *Vendors Accuse Qualcomm of Squeezing UMTS Market*, WIRELESS REV., Oct. 20, 2005, http://telephonyonline.com/wireless/news/qualcomm_umts_market_102805/index.html; see also Mark LaPedus, *Japan FTC to Investigate Qualcomm's Practices*, ELEC. ENG'TS TIMES, Nov. 13, 2006, http://www.eetasia.com/ART_8800441497_499488_3b0608ab200611.htm. Authors Farrel, Hayes, and Shapiro have been involved in proceedings against Qualcomm in some of these cases.

¹⁹ *Broadcom Corp. v. Qualcomm Inc.*, 501 F.3d 297, 305-06, 323 (3d Cir. 2007).

²⁰ *Townshend v. Rockwell Int'l Corp.*, 55 U.S.P.Q.2d (BNA) 1611, 1614 (N.D. Cal. Mar. 28, 2000). The ITU patent policy states that, first, "any ITU-T member organization putting forward a standardization proposal should, from the outset, draw the attention of the Director of ITU-TSB . . . to any known patent or to any known pending patent application, either their own or of other organizations. . ." ITU TELECOMM. STANDARDIZATION SECTOR, COMMON PATENT POLICY FOR ITU-T/ITU-R/ISO/IEC ¶ 1 (2007), <http://www.itu.int/ITU-T/dbase/patent/patent-policy.html>. Then, for any standard containing patented technology to be adopted, the patent holder must provide a written statement that he either waives his rights to enforce his patent, or "is willing to negotiate licences with other parties on a non-discriminatory basis on reasonable terms and conditions." *Id.* ¶¶ 2.1, 2.2, 3.

²¹ *Motorola, Inc. v. Rockwell Int'l Corp.*, No. 95-575-SLR (D. Del. 1995). Authors Shapiro and Sullivan were retained by Rockwell in that case.

Standards and patents are very important in information technology, but not only there. The FTC alleged that Unocal's misrepresentations to the California Air Resources Board (CARB) regarding Unocal's patent applications on reformulated gasoline (RFG) led CARB to adopt an RFG formula that infringed Unocal's patents, on which Unocal then sought royalties.²²

This article discusses economic issues raised by the licensing of patents in standards. The closely related legal issues have been addressed in FTC/DOJ hearings²³ and in law journals.²⁴

Central to this analysis is what Oliver Williamson called the "fundamental transformation."²⁵ Ex ante, before an industry standard is chosen, there are various attractive technologies, but ex post, after industry participants choose a standard and take steps to implement it, alternative technologies become less attractive. Thus, a patent covering a standard may confer market power ex post that was much weaker ex ante. In

²² Complaint at ¶¶ 1–6, Union Oil Co. of Cal., FTC Docket No. 9305 (Mar. 4, 2003) [hereinafter *Unocal Complaint*]. *Unocal* was resolved in 2005 with a consent order in which Unocal agreed to cease enforcement of its patents. Union Oil Co. of Cal., FTC Docket No. 9305, 2005 FTC LEXIS 116, at *6 (July 27, 2005). Author Shapiro testified on behalf of the FTC's complaint counsel in this case; author Hayes was also retained by the FTC.

²³ See U.S. Dep't of Justice & Fed. Trade Comm'n, Hearings on Competition and Intellectual Property Law in the Knowledge-Based Economy, tr. at 3–92 (Nov. 06, 2002) ("Antitrust Law and Patent Landscapes: Standard Setting Organizations, Evaluating the Anticompetitive Risks of Negotiating IP Licensing Terms and Conditions Before a Standard is Set") [hereinafter FTC/DOJ Hearings on Standard-Setting Organizations], available at <http://www.ftc.gov/opp/intellect/021106ftctrans.pdf>; see also U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, ANTITRUST ENFORCEMENT AND INTELLECTUAL PROPERTY RIGHTS: PROMOTING INNOVATION AND COMPETITION 33–56 (2007) [hereinafter DOJ/FTC IP REPORT], available at <http://www.usdoj.gov/atr/public/hearings/ip/222655.pdf>.

²⁴ See M. Sean Royall, *Standard Setting and Exclusionary Conduct: The Role of Antitrust in Policing Unilateral Abuses of Standard-Setting Processes*, ANTITRUST, Spring 2004, at 44; M. Howard Morse, *Standard Setting and Antitrust: The Intersection Between IP Rights and the Antitrust Laws*, IP LITIGATOR, May 2008, at 1, http://www.accessnylibrary.com/comsite5/bin/comsite5.pl?page=document_print&item_id=0286-23665119&purchase_type=IP&action=print; see generally Robert Skitols, *Concerted Buying Power: Its Potential for Addressing the Patent Hold-up Problem in Standard Setting*, 72 ANTITRUST L.J. 727 (2005); Gil Ohana et al., *Disclosure and Negotiation of Licensing Terms Prior to Adoption of Industry Standard: Preventing Another Patent Ambush*, 12 EUR. COMPETITION L. REV. 644 (2003); Michael Cowie & Joseph Lavelle, *Patents Covering Industry Standards: The Risks to Enforceability Due to Conduct Before Standard Setting Organizations*, 30 AIPLA Q.J. 95 (2002); David Teece & Edward Sherry, *Standards Setting and Antitrust*, 87 MINN. L. REV. 1913 (2003); Joseph Kattan, *Antitrust Implications: Disclosure and Commitments to Standard-Setting Organizations*, ANTITRUST, Summer 2002, at 22; Mark Lemley, *Intellectual Property Rights and Standard-Setting Organizations*, 90 CAL. L. REV. 1889 (2002) [hereinafter *Intellectual Property Rights*]; Janice M. Mueller, *Patent Misuse Through the Capture of Industry Standards*, 17 BERKELEY TECH. L.J. 623 (2002).

²⁵ OLIVER WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM: FIRMS, MARKETS, RELATIONAL CONTRACTING 61–68 (1985).

the extreme, a standard could be built around initially arbitrary choices that become essential once the standard is established.²⁶ As FTC Chairman Majoras put it, and as we discuss further in Part II:

If, at the start of the process, any one of a number of competing formats could win the standards battle, then no single format will command more than a competitive price. But standardization can change that dynamic. After the standard is chosen, industry participants likely will start designing, testing, and producing goods that conform to the standard—that is, after all, the whole idea of engaging in standard setting. Early in the standardization process, industry members might easily be able to abandon one technology in favor of another. But once the level of resources committed to the standard rises and the costs of switching to a new technology mount, industry members may find themselves locked into using the chosen technology. In that case, competition for the standard ends (at least for a time, until, for example, the next generation of technology supplants it).²⁷

Standards hold-up is both a private problem facing industry participants and a public policy problem. Privately, those who will implement the standard (notably manufacturers of standard-compliant equipment) do not want to be overcharged by patent holders. Nor do they want to be forced by concerns about hold-up to eschew the best technology just because it is patented, or to attempt difficult and perhaps inefficient ex ante negotiation. Both they and patent holders generally have an interest in limiting suspicion and vested interest in the standards process. But standards hold-up is also a public policy concern because downstream consumers are harmed when excessive royalties are passed on to them. Downstream consumers also can be harmed when other burdensome terms are imposed in patent licenses and when cumulative innovation is retarded by patent hold-up.

²⁶ Ex ante arbitrary choices (with minimal ex ante advantage) may be most likely where a copyright, rather than a patent, is involved. In the *Lotus-Borland* litigation, once Lotus's copyrighted interfaces became a de facto standard, Lotus arguably acquired market power beyond that intended by copyright policy or warranted (according to any market test) by the quality of the interfaces. See Joseph Farrell et al., Brief Amicus Curiae of Economics Professors and Scholars in Support of Respondent at *4, *Lotus Dev. Corp. v. Borland Int'l, Inc.*, 516 U.S. 233 (Dec. 1995) (No. 94-2002). On copyright and standards, see generally Pam Samuelson, *Questioning Copyright in Standards* (Berkeley Ctr. for Law and Tech., Working Paper 22, 2006), available at <http://repositories.cdlib.org/bclt/lts/22/>.

²⁷ Deborah Platt Majoras, Chairman, Fed. Trade Comm'n, Recognizing the Procompetitive Potential of Royalty Discussions in Standard Setting, Remarks at Conference on Standardization and the Law: Developing the Golden Mean for Global Trade, Stanford Univ. (Sept. 23, 2005), available at <http://www.ftc.gov/speeches/majoras/050923stanford.pdf>.

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This is not merely a private contracting problem, but an antitrust problem. It concerns the inefficient acquisition of market power that harms consumers; more fundamentally, deceiving buyers or keeping them in the dark about the terms on which a technology will be available subverts the competitive process. In that process, buyers negotiate with and/or choose among sellers (here, technology sponsors); this process is undermined if buyers are deceived or manipulated into a deal that they did not knowingly choose. In this environment, how can antitrust enforcement help preserve or repair the competitive process? We focus on (a) how antitrust policy can help ensure that well-informed negotiation and technology choice are not artificially thwarted, and (b) how, if such choice fails to occur, one might seek (inevitably imperfectly) to replicate its results. Because the competitive process is driven by buyer choice, this demands attention to what buyers (here, technology adopters) want, but it does not mean adopting a narrow buyer-welfare standard.²⁸

Many standard-setting organizations have rules relevant to the patent hold-up problem.²⁹ These rules cluster in three areas, as we discuss in Part III: *disclosure rules*, requiring certain disclosures of patents or patent applications; *negotiation rules*, regarding the timing and locus of license negotiations; and *licensing rules*, governing the level and structure of royalties, most often requiring participants to license essential patents on "Fair, Reasonable and Non-Discriminatory" (FRAND) or "Reasonable and Non-Discriminatory" (RAND) terms.

Even with good intentions, it is difficult for an SSO to craft and enforce fully effective rules along those lines. Moreover, while SSOs' rules have been used as a salient benchmark for "bad acts" in legal disputes, economic analysis does not suggest that competition policy should completely defer to those private rules. If an SSO's incentives are not aligned with those of consumers, one would not necessarily expect the SSO participants to craft rules that protect consumers, much as, if one

²⁸ In particular, a buyer-welfare standard would seek to expropriate innovators' quasi-rents, which a customer choice analysis does not. On total-welfare and consumer-welfare standards in antitrust, see generally Kenneth Heyer, *Welfare Standards and Merger Analysis: Why Not the Best?*, COMPETITION POLY INT'L, Autumn 2006, at 29, available at <http://www.globalcompetitionpolicy.org/index.php?id=76&action=907>; Joseph Farrell & Michael L. Katz, *The Economics of Welfare Standards in Antitrust*, COMPETITION POLY INT'L, Autumn 2006, at 3 [hereinafter *Welfare Standards*], available at <http://www.globalcompetitionpolicy.org/index.php?id=77&action=907>.

²⁹ For reviews of the policies of a large number of SSOs, see generally Lemley, *Intellectual Property Rights*, *supra* note 24; Benjamin Chao et al., *The Rules of Standard Setting Organizations: An Empirical Analysis*, RAND J. ECON. (forthcoming), available at http://idei.fr/doc/by/tirole/setting_organizations.pdf.

allowed drivers to set posted speed limits, one could not assume that the limits they set would adequately protect pedestrians. And even staying below the speed limit does not prevent a driver from liability if he recklessly causes an accident. One can follow some rules and still be responsible for harm.

We focus on the competitive process, not on theoretically optimal intellectual property policy, but we also discuss innovation incentives. While any policy that constrains patent holders could reduce innovation incentives, the patent system should not and does not seek simply to *maximize* the reward to patent holders; rather, it properly seeks broadly to *align* innovation incentives with the innovator's contribution, while keeping in mind collateral damage *ex post*. Below, we explain why allowing patentees to extract gains from hold-up would not help align incentives.³⁰ This economic argument resonates with the natural concept that *ex ante* market power is a just or suitable reward to a patentee for its innovation, but *ex post* enhancement of market power through hold-up is not.

Similarly, although rules to limit *ex post* hold-up may discourage some patent holders' participation in SSOs, participation is beneficial *because* (and *if*) it ultimately promotes economic efficiency and benefits consumer welfare, not because it is intrinsically good. The rules must therefore balance the goal of limiting hold-up against the danger that overly strong rules might discourage participation and thus risk greater opportunism by outside patent holders. Competition policy and SSO rules can only go so far to solve these problems. Patent reform could play at least as large a role by improving patent quality, expanding the independent invention defense, and in some cases limiting patent holders' ability to obtain injunctions.³¹

II. ECONOMICS OF PATENTS AND OPPORTUNISM

In normal, well-functioning markets, well-informed buyers choose what is best for them among offers freely made by sellers. We ask how SSO rules and public policy can help preserve or, where they cannot preserve, replicate such a well-functioning technology market. As a key

³⁰ Although most of our discussion will focus on royalties, the problem of hold-up can also manifest itself in other licensing terms, such as overly broad grantbacks. Ill-gotten monopoly power that is exercised in some way other than through excessive royalties is still problematic.

³¹ See Carl Shapiro, *Patent Reform: Aligning Reward and Contribution*, in 7 INNOVATION POLICY AND THE ECONOMY 119, 193–203 (Adam Jaffe et al. eds., 2007) [hereinafter *Aligning Reward and Contribution*] (independent invention defense); *id.* at 204–09 (improving patent quality); *id.* at 209–10 (selectively limiting injunction).

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part of that analysis, we discuss technology choice by a producer downstream. We stress the difference between the reward to a patent holder based on its innovation and patent, and the potential extra return based on hold-up. We then discuss how, in practice, one might measure the increment to market power that arises from hold-up.

A. PATENTS: REWARDS ALIGNED WITH ADDED VALUE

Economic incentives generally work well when each person's or firm's reward for its actions is broadly commensurate with the incremental contribution of those actions to total economic surplus. When a firm builds a new sawmill, it gets the exclusive right to use the mill—a property right that it can exploit itself, license out (e.g., by leasing or selling the mill to others or by producing for others under contract), or let it lie fallow. In economic terms, this property rule broadly (though often imperfectly) aligns the builder's reward with its economic contribution. In particular, the builder's reward will depend on what the sawmill contributes by way of, for example, reduced operating costs (superior plant and machinery) or reduced transportation costs (convenient location). If it contributes value in these ways, then the mill owner will be rewarded for these contributions by profitably attracting users to whom it offers higher value than do rival sawmills. Thus, its profit reflects the value that it contributes to total surplus.

In economics, intellectual property policy is understood as seeking to make this broad alignment of rewards and contributions also work in the field of innovation where, without such policy, it might well fail. If others could freely use an invention, the inventor's reward might well be much less than the invention's contribution. In a highly competitive industry with rapid copying and diffusion of unprotected innovations, the inventor's reward could be nearly zero.³²

Of course, the same could be said of the sawmill builder if rivals could freely use the mill. This reasoning suggests applying the same property regime to innovations as to sawmills. While this would be a grossly oversimplified view of good intellectual property policy, the analogy is helpful: a patent rewards innovators by giving them exclusive rights, just as ordinary property rewards sawmill builders that way. Both can align re-

³² Generally, in a highly competitive industry without binding capacity constraints, a firm's rewards are relativistic: they stem from being better than its rivals and are not very sensitive to the industry-wide level of unit costs. Thus, if one firm invents a lower-cost production technique that can be adopted by all without paying, no firm benefits much (although consumers do). Thus, neither a participant nor a pure upstream inventor has much incentive to innovate. In a less competitive industry, even one with some rivalry, all firms (plus consumers) typically gain if all become more efficient.

wards fairly well when there is a good market test of the invention's, or the mill's, superiority to the alternatives.

For example, consider the choice between a patented production technology and an unpatented alternative.³³ The two technologies yield the same output, so the technology user simply seeks to minimize cost. Suppose that the patented technology requires the user to bear costs of \$40, not including any royalty, and the alternative technology requires the user to bear costs of \$50. The user would be willing to pay a royalty of up to the patented technology's inherent advantage of \$10. This inherent advantage typically allows the patent holder profitably to charge a positive price (more generally, a price above marginal cost), perhaps \$6 in this example. We denote this legitimate market power (although some antitrust practitioners are squeamish about such usage) by MP_A . As will become clear just below, the subscript A refers to the *ex ante* situation before users have sunk specific investments, and the subscript P refers to the *ex post* situation after users have sunk specific investments.

If the patent holder demands more than its inherent advantage, V_A , the user will choose the alternative, unpatented technology. Thus, $MP_A \leq V_A$, with MP_A set in any particular case according to the normal competitive process for dividing joint surplus. Below, we will sometimes refer to the ratio MP_A/V_A as the patent holder's bargaining skill.

B. SPECIFIC INVESTMENTS AND HOLD-UP

Unfortunately, the market test fails when a patent holder can demand royalties after users have sunk specific investments in the course of beginning (or preparing) to use the patented technology.³⁴ It is as if the sawmill owner set its prices only after a logger transported its logs to the mill, unloaded them, and sent its trucks away.

In our example, suppose that, of the \$40 cost of using the patented technology, \$25 was spent before the royalty was negotiated and that this \$25 is specific to the patented technology, i.e., would be wasted if the user later decided against adopting that technology.³⁵ Then, at the time of negotiations, the forward-looking cost of using the patented technol-

³³ A similar but more complex analysis would apply to the choice between two or more patented alternatives.

³⁴ There are many reasons why returns to patents may be higher or lower than optimal. This article is limited to situations involving hold-up.

³⁵ A specific investment in a technology is one that has less (or no) value if the user switches to an alternative technology. Thus, the \$25 is "wasted" in the sense that if the user decides later to employ an alternative technology, he does not gain anything from having already spent \$25 on the patented technology.

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ogy (exclusive of royalty) is $\$40 - \$25 = \$15$, while the cost of using the unpatented technology remains $\$50$ (the $\$25$ already spent has no value if the user adopts the alternative technology). As above, the maximum royalty that the user is willing to pay remains the added value of the patented technology, but with the key difference that this amount is now $\$50 - \$15 = \$35$, or $\$25$ more than in our first calculation. Ex post negotiation increases the user's willingness to pay for the patented technology because the user finds the alternative relatively less attractive after spending $\$25$ on the patented technology.³⁶ The patented technology's ex post advantage V_p exceeds its inherent advantage V_A by an amount equal to the user's $\$25$ investment. If the patent holder's bargaining skill does not change, this increase will cause a parallel increase in market power, from MP_A ex ante to MP_p ex post. The patent holder thus captures a share (proportional to its bargaining skill) of sunk investments by the user. Economists call this hold-up or opportunism.³⁷

1. More General Analysis of Specific Investments

The Appendix analyzes more formally how such economic factors cause patent hold-up and affect its extent. Where the user makes specific investments before negotiating with the patent holder, the resulting hold-up equals the value of those specific investments multiplied by the patent holder's bargaining skill.³⁸ Thus, hold-up increases with the difference $V_p - V_A$ between the technology's subsequent and inherent advantages, and with the patent holder's bargaining skill. The smaller the fraction of incremental ex post joint surplus that the user can appropriate (as is likely with multiple patent holders and royalty stacking), the greater is the hold-up.

2. Uncertainty About Benefits and Costs

The Appendix also analyzes a simple model of uncertainty about the benefits and costs of the competing technologies. In a simple but cen-

³⁶ We assume that the user's best alternative ex ante remains the best alternative ex post, although its attractiveness or value diminishes. The analysis can be extended to situations where the best alternative changes.

³⁷ A fallacy here would be to mis-apply the economic slogan that "sunk costs don't matter." Here, the by-then-sunk costs will not matter in the ex post bargaining, so that bargaining will proceed just as if there had been no specific investment and the cost of using the patented technology were only $\$15$. But due to the sunk costs, this ex post bargaining will be quite different from the ex ante bargaining. Ex ante, when the $\$25$ is not yet sunk, the fact that $\$25$ of the total cost of using the technology will be spent before negotiation and $\$15$ after does matter. In this sense, sunk costs matter.

³⁸ It is the value in use (with the patented technology) of those investments, minus any value in an alternative use, that counts, not the amount spent. For a rational user, the anticipated value in use is presumably at least equal to the amount spent.

tral case, it shows that the expected overcharge equals the same amount just calculated in the case without uncertainty.³⁹ This is the natural first cut at the incentive for patent holders to engage in opportunistic behavior.⁴⁰

3. Reduced Value from Adopting Alternative Technology

If a user initially pursues the patented technology and much later, dissatisfied with royalty negotiations, changes course and adopts the alternative, the latter's benefits may be importantly delayed. The user's ex post alternative is less attractive than it was initially because the value of adopting the alternative technology must be discounted due to delay. The Appendix calculates that the patented technology's ex post advantage V_p then includes not only the user's (explicit) specific investments in the patented technology, but also any delay-induced *loss* in the value available from the alternative technology, such as an opportunity cost arising from delaying commercial introduction of a product.

4. Additional Sources of Hold-Up

Other predictable changes can occur in the interim between initial commitment to the patented technology and ex post royalty negotiations. For example:

(a) *Learning by doing*—declining costs as producers gain experience with production—is common in high-technology industries where standards are important, such as the DRAM industry.⁴¹ Learning by doing that is specific to the patented technology contributes to the gap between the ex ante and ex post values of the patented technology because a delayed switch to the alternative technology would leave users higher on the new learning-based cost curve. Extending our previous example, suppose that of the \$25 “spent” before the royalty was negotiated, \$15 was explicitly spent on equipment and \$10 was saved on future production costs by learning how to use it. As before, the user is now willing to pay as much as \$35 for the patented technology. This investment and learning can be held hostage by the patent holder.

³⁹ With uncertainty, the actual ex post advantage may be larger or smaller than the expected advantage. See the section in the Appendix discussing uncertainty for more details on this distinction.

⁴⁰ On the other hand, measurement of the increment to market power should be based on the actual, realized overcharge that results from opportunism. Measurement of market power is discussed in more detail below.

⁴¹ There is a sizable literature on learning by doing in the semiconductor industry. For an early study, see HAROLD GRUBER, LEARNING AND STRATEGIC PRODUCT INNOVATION: THEORY AND EVIDENCE FOR THE SEMICONDUCTOR INDUSTRY (1994).

(b) *Investments in complements* specific to the patented technology, by this user or others, can also create a gap between ex ante and ex post values.⁴² In our example, suppose that in addition to the user's \$25 investment, additional investments in complements were made by other producers, raising demand for output from the patented technology (but not the alternative technology) by \$5. Now, in ex post negotiation, the producer would be willing to pay up to $V_p = \$50 - \$15 + \$5 = \40 ; the $V_A = \$10$ inherent advantage of the patented technology plus the \$30 resulting from specific investments (\$25 on the patented technology plus \$5 on complements). As before, the overcharge will be equal to the increase in willingness to pay, times the patent holder's bargaining skill.

C. RELATIONSHIP OF HOLD-UP TO TECHNICAL SUPERIORITY

We distinguish market power based on hold-up from market power based on the patented technology's inherent advantage. The latter advantage and the market power MP_A are presumed to be a legitimate return to the patent holder's innovation. Market power based on hold-up is the difference Δ between this legitimate market power and the ex post market power: $\Delta = MP_p - MP_A$.

If the patented technology would be chosen under fully informed ex ante competition, perhaps because it is technically superior, it may be tempting to reason that hold-up causes no harm. But, while in this case hold-up does not distort technology choice, it will normally inflate the royalties that are paid for it (from \$10 to \$35 in our initial example). Even if the user had no commercially viable ex ante alternative to the patented technology, it still had an alternative: not to go forward with new products. In this case, if the patent holder has a lot of bargaining skill, the user would *lose* money from adopting the patented technology and negotiating royalties *ex post*, compared to the alternative of not going forward. As this suggests, the *prospect* of hold-up may induce users to postpone or avoid making commitments, and this is part of the economic harm that hold-up causes. Users may also make inefficient investments to partially protect themselves from possible hold-up.

⁴² Complementary investments are often crucial to developing the complex systems of related technologies that characterize many high-technology industries. DRAM, for example, plugs into motherboards and communicates with microprocessors through standardized interfaces. Part of the investment in motherboards and microprocessors is specific to the DRAM technology used. DRAM manufacturers are reluctant to abandon a technology standard, in part because of resistance from complementary suppliers.

D. HOLD-UP CAN BE ESPECIALLY SEVERE FOR INDUSTRY STANDARDS

Hold-up is a particular problem in the context of cooperative standard setting for two reasons. First, when standards are involved, an entire industry may make specific investments that are subject to hold-up. Second, coordination problems can make it especially hard to shift away from an agreed-upon standard in response to excessive royalty demands.⁴³

If each user's leading alternative to sticking with the standard is unilateral switching, and thus losing compatibility with others, then the patent holder's subsequent advantage V_p includes not only its technology's inherent advantage and the value of the user's own sunk investments, but also the value of compatibility to the user.⁴⁴ For example, compliance with some telecommunications standards enables a network operator to offer its customers the ability to roam onto compatible networks. In our numerical example, suppose that the two technologies produce incompatible, though otherwise identical, outputs, and that compatibility with other users is worth \$30. Then, if all others are expected to stick to the patented technology, adopting it is worth \$30 more to each user. The user will adopt the patented technology as long as the royalty demanded is less than \$40, composed of \$10 of inherent value and \$30 of network effect.⁴⁵

In other cases, users' best alternative to ex post licenses may be a coordinated shift to a new standard, perhaps via reconsideration by the SSO itself.⁴⁶ However, SSO processes take a long time.⁴⁷ Indeed, SSOs seem

⁴³ See *Rambus Inc.*, Opinion of the Commission, *supra* note 10, at 102. Rysman and Simcoe use patent citation data to show that patents selected in standards receive more citations over a longer period of time than a set of control patents, and not all of this difference is because SSOs presumably select superior technologies. In other words, patents become more widely cited *because* they are selected for inclusion in standards. Marc Rysman & Tim Simcoe, *Patents and the Performance of Voluntary Standard Setting Organizations* (NET Institute Working Paper No. 05-22, Oct. 11, 2005), available at <http://ssrn.com/abstract=851245>.

⁴⁴ See, e.g., Joseph Farrell & Michael L. Katz, *The Effects of Antitrust and Intellectual Property Law on Compatibility and Innovation*, 43 ANTITRUST BULL. 609, 610-11 (1998) [hereinafter *Compatibility and Innovation*].

⁴⁵ On the other hand, if all others have adopted the alternative technology, then the user is unwilling to adopt the patented technology even at zero royalties. With strong network effects (as here), only with ex ante negotiations, before the industry collectively adopts a standard, can we have a market test in which the patented technology is neither inefficiently frozen out nor endowed with hold-up power.

⁴⁶ Coordination might be especially difficult to achieve if the patent holder engaging in ex post opportunism builds a supporting coalition through rewards offered to selected licensees.

⁴⁷ Development of the 3G GSM (W-CDMA) standard, for example, took over three years. Rudi Bekkers & Joel West, *The Effect of Strategic Patenting on Cumulative Innovation in*

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very reluctant to revisit standards already adopted, in part because they are slow to move, rely on consensus, and typically have already begun work on more advanced standards that build upon the prior standard.⁴⁸ In the language of the economics of standards, hold-up can be severe if there is substantial (or strong) inertia. Moving from one standard to another is often costly and disruptive, and, thus, it is *ex post* both normal and efficient for an industry to be reluctant to make such a shift.⁴⁹ Of course, this does not imply that exploiting that reluctance is efficient.

A recent court decision, *Golden Bridge v. Nokia*,⁵⁰ may make SSO participants even more reluctant to change a standard. Golden Bridge owns patents covering the CPCH technology, which allows the transfer of medium-sized packets between cellular phones and base stations. According to the opinion, in 1999, 3GPP included CPCH as an optional feature of a WCDMA standard. After Golden Bridge's patents issued and it began to negotiate license agreements, the SSO participants removed CPCH from the standard at a meeting that Golden Bridge (a member) did not attend. Golden Bridge alleged that the other participants had conspired to avoid paying royalties. The court refused to grant a motion to dismiss, holding that participants in the SSO may have committed a *per se* violation of the antitrust laws by changing the standard to remove CPCH technology.⁵¹ A DOJ official has commented that "the mere decision to choose a different technology for reasons of technological merit,

UMTS Standardization 9, tbl. I (DIME, Working Paper No. 9, 2006), available at http://ipr.dime-eu.org/ipr_publications. See also UMTSWorld.com, The History of UMTS and 3G Development, <http://www.umtsworld.com/umts/history.htm> (presenting a timeline of significant milestones in the development and implementation of 3G GSM). Development of the 2G GSM standard took over five years. See Beckers et al., *Intellectual Property Rights, Strategic Technology Agreements and Market Structure: The Case of GSM 15–16* (Eindhoven Center for Innovation Studies, Working Paper, Sept. 2000), available at <http://www.merit.unu.edu/publications/rmpdf/2000/rm2000-030.pdf>; see also GSMWorld.com, Brief History of GSM and the GSMA, <http://www.gsmworld.com/about/history.shtml> (presenting a timeline of significant milestones in the development and implementation of 2G GSM).

⁴⁸ For example, 3G GSM builds upon, and is backward compatible with, the 2G GSM standard.

⁴⁹ A related, but different, question is whether the equilibrium outcome exhibits *excess* inertia. Broadly speaking, the economics literature has shown that equilibrium inertia can, but need not, exceed what is *ex post* efficient. See, e.g., Joseph Farrell & Paul Klemperer, *Coordination and Lock-In: Competition with Switching Costs and Network Effects*, in 3 HANDBOOK OF INDUSTRIAL ORGANIZATION 2029–39 (Mark Armstrong & Robert Porter eds., 2007), available at http://www.nuff.ox.ac.uk/users/klemperer/Farrell_Klemperer_WP.pdf. Both equilibrium and efficient levels of inertia may be sufficient to enable substantial hold-up.

⁵⁰ *Golden Bridge Tech., Inc. v. Nokia, Inc.*, 416 F. Supp. 2d 525 (E.D. Tex. 2006).

⁵¹ *Id.* at 532, 535.

price, or any other normal condition does not" state an antitrust claim,⁵² but the court's refusal to dismiss the claim may make SSOs even more reluctant to revisit standards to escape patent hold-up.

E. PROBABILISTIC PATENTS

Many litigated patents are found invalid or unenforceable,⁵³ and presumably many unlitigated patents are also weak. Weak patents can improperly reward inventions that are "obvious" or are not "novel," at the expense of consumers who pay supracompetitive prices.⁵⁴ Even if a patent has been issued and is disclosed to the SSO, its validity and effective scope may be unknown when the standard is selected and implemented. This is all the more true of patent applications, an especially serious problem given the widespread use of continuation applications at the PTO.⁵⁵

Weak patents pose a special risk of hold-up if adopters could not readily switch away from a patented technology *after* it is litigated and (despite *ex ante* weakness) found valid.⁵⁶ Even straightforward and costless *ex ante* negotiations and agreements would reflect the hold-up anticipated if no *ex ante* agreement were reached and the patent were found valid. To understand this, one must ask what would happen with no *ex ante* agreement. If hard-to-reverse product design choices must be made before the patent's validity or scope can be ascertained, users must effectively choose between using the patented technology and avoiding it. If the patent is weak, a rational user will prefer to use the technology, since royalties will probably never be due. Then, if the patent eventually does

⁵² Gerald F. Masoudi, Deputy Ass't Att'y Gen., Antitrust Div., U.S. Dep't of Justice, Address at High Level Workshop on Standardization, IP Licensing, and Antitrust: Efficiency in Analysis of Antitrust, Standard Setting, and Intellectual Property 11 (Jan. 18, 2007), available at <http://www.usdoj.gov/atr/public/speeches/220972.pdf>.

⁵³ See FED. TRADE COMM'N, TO PROMOTE INNOVATION: A PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY ch. 5, at 6 (2003), available at <http://www.ftc.gov/os/2003/10/innovationrpt.pdf>; Iain M. Cockburn et al., *Are All Patent Examiners Equal? Examiners, Patent Characteristics, and Litigation Outcomes*, in *PATENTS IN THE KNOWLEDGE-BASED ECONOMY* 38 (Wesley M. Cohen & Stephen A. Merrill eds., 2003).

⁵⁴ Lemley and Shapiro provide an overview of issues arising from probabilistic patents and cite relevant evidence. See generally Mark Lemley & Carl Shapiro, *Probabilistic Patents*, J. ECON. PERSP., Spring 2005, at 75. [hereinafter *Probabilistic Patents*]. Farrell and Shapiro show that a weak patent can command a royalty that is disproportionate to the patent's strength. Joseph Farrell & Carl Shapiro, *How Strong Are Weak Patents?* AM. ECON. REV. (forthcoming 2008), available at <http://repositories.cdlib.org/iber/cpc/CPC05-54>.

⁵⁵ Mark Lemley, *Ten Things to Do About Patent Hold-up of Standards (and One Not To)*, 48 B.C. L. REV. 149 (2007).

⁵⁶ See Carl Shapiro, *Injunctions, Hold-Up, and Patent Royalties* 3 (Univ. of Cal., Berkeley, Competition Pol'y Ctr., Working Paper No. CPC06-062, 2006), available at <http://repositories.cdlib.org/iber/cpc/CPC06-062/>.

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prove valid and infringed, hold-up ensues. The user's expected cost of *not* negotiating an ex ante license, thus, includes the risk of hold-up, and negotiated terms for an ex ante license will reflect this.

F. MEASUREMENT OF HOLD-UP POWER

1. *Specific Investments Partially Measure Hold-up Power*

One may be able to measure hold-up power that stems directly from a user's investments that are specific to the patented technology.⁵⁷ To do so, one would need to estimate the (technology-specific) value of those investments and the patent holder's bargaining skill. The former gives the increase $V_p - V_A$ in users' value of the patented technology (relative to alternatives). The latter may not be easy to estimate, but one could derive bounds, or as a default one could take it to be equal to the bargaining skill of the user. If bargaining skill does not increase, then $\Delta = MP_p - MP_A \leq V_p - V_A$.

We illustrate using the *Unocal* case.⁵⁸ The California Air Resources Board (CARB) adopted a standard for reformulated gasoline (RFG) intended to reduce automobile pollution. With limited exceptions, only CARB RFG could be sold within California. After California refiners had invested approximately \$4 billion to comply with the CARB regulations,⁵⁹ Unocal announced that it had patents covering the standard and that it sought royalties.⁶⁰ At roughly the same time that CARB was developing its gasoline formulation, the U.S. Environmental Protection Agency (EPA) was also developing a reduced pollution RFG.⁶¹ Evidence

⁵⁷ As noted above, network effects and coordination costs also contribute to hold-up power, so measuring specific investments alone will *underestimate* the increment to market power in their presence, potentially yielding a useful lower bound estimate if countervailing factors are not too important.

⁵⁸ The Commission in *Rambus* also examined evidence of specific investment to determine the extent of hold-up. *Rambus Inc.*, Opinion of the Commission, *supra* note 10, at 112–13.

⁵⁹ Refiner investments are reported in CALIFORNIA AIR RESOURCES BOARD, ASSESSMENT OF THE LOCAL AND REGIONAL EMISSION IMPACTS FROM CALIFORNIA PHASE 2 REFORMULATED GASOLINE AND RELATED CLEAN FUELS REFINERY MODIFICATIONS I (Jan. 2003).

⁶⁰ Unocal sought royalties of 5.75 cents per gallon for litigating refiners and fees ranging from 1.2 to 3.4 cents per gallon for "non-litigating" refiners. See *Unocal* Complaint, *supra* note 22, ¶ 9.

⁶¹ In 1991, the EPA convened a rulemaking committee composed of representatives from regulatory agencies, industry, and environmental groups to agree on a standard for RFG that met the Clean Air Act's requirements. See generally Regulation of Fuels and Fuel Additives: Standards for Reformulated Gasoline; Notice of Proposed Rulemaking (July 9, 1991), available at <http://www.epa.gov/otaqregs/fuels/rfg/56-31176.txt>.

at trial indicated that EPA RFG was an alternative available to CARB RFG.⁶²

Given appropriate data, one can compute the expected increment to Unocal's ex post market power attributable to hold-up arising from specific investments.⁶³ Thus, Table 1 estimates the additional capital cost per gallon borne by refineries to comply with CARB's RFG regulations, as compared to the capital cost that would have been incurred to comply with the EPA rules. As shown there, these costs come to roughly \$1.5 billion for the eight leading refiners, or somewhat less than two cents per gallon, once the capital costs are amortized.⁶⁴ Table 1 explicitly reports the CARB-specific capital costs by excluding the capital costs necessary to comply with EPA RFG regulations and by excluding "discretionary" capital spending undertaken during the same period.⁶⁵

2. *Switching Costs and Hold-up Power*

The FTC in *Rambus* concluded from testimony on switching costs that when Rambus revealed its intention to collect royalties, DRAM suppliers would have needed to invest hundreds of millions of dollars to switch to alternative, non-infringing DRAM technologies.⁶⁶

If switching costs mean the costs of achieving equivalent performance without infringing the patent, then they reflect the technology's ex post advantage V_p , an upper bound on ex post power MP_p , and thus overestimate the hold-up component, $\Delta = MP_p - MP_A$, of ex post power if the

⁶² Complaint Counsel's Post-Trial Brief 117, 145, Union Oil Company of California, FTC Docket No. 9305 (Mar. 9, 2003), *available* at <http://www.ftc.gov/os/adjpro/d9305/030309ecpattrialbrief.pdf>. California refiners were also required to comply with the EPA RFG regulations. CARB's RFG requirements went beyond those adopted by the federal government. Thus, if California had not adopted its own RFG, refiners still would have been required to comply with EPA rules. *See id.* at 117. Unocal argued that CARB failed to "consider[] any regulatory options to facilitate patent avoidance even though such options existed." Respondent's Post-Trial Brief 257, Union Oil Company of California, FTC Docket No. 9305 (Mar. 14, 2003) [hereinafter *Unocal Respondent's Post-Trial Brief*], *available* at <http://www.ftc.gov/os/adjpro/d9305/050314resposttrialbrief.pdf>.

⁶³ Shapiro testified that an additional increment to Unocal's ex post market power was attributable to unanticipated operating cost savings associated with CARB RFG. Trial Trans. at 7085, Union Oil Company of California, FTC Docket No. 9305 (Jan. 12, 2003) (testimony of Carl Shapiro) [hereinafter *Shapiro Unocal Testimony*].

⁶⁴ California Air Resources Board, Proposed Regulations for California Phase 2 Reformulated Gasoline: Technical Support Document f34 (Oct. 4, 1991).

⁶⁵ These data are based on testimony by FTC technical expert Michael Sarna. *See* Expert Report of Michael E. Sarna at 27, Union Oil Company of California, FTC Docket No. 9305 (undated); Trial Trans. at 6189, Union Oil Company of California, FTC Docket No. 9305 (Dec. 20, 2004) (discussing Sarna Expert Report).

⁶⁶ *Rambus Inc.*, Opinion of the Commission, *supra* note 10, at 102–04. The Commission also noted that producers of complementary goods would also face substantial switching costs that could exceed those faced by DRAM suppliers.

TABLE 1: CARB-SPECIFIC INVESTMENTS

Refinery	Location	Capital Investment (millions)	Annualized Capital Cost (cents per gal)
Arco (BP)	Carson	\$330	2.21
Chevron (ChevronTexaco)	El Segundo	\$228	1.45
Chevron (ChevronTexaco)	Richmond	\$330	2.18
Exxon (Valero)	Benicia	\$193	2.31
Mobil (ExxonMobil)	Torrance	\$57	0.58
Shell	Martinez	\$286	3.01
Texaco (Shell)	Wilmington	\$83	1.34
Texaco (Shell)	Bakersfield	\$21	0.54
Aggregate for 8 refineries		\$1,528	1.83

Sources:

- (1) 1994 refiner crude capacity data from CARB, "Assessment of the Local and Regional Emission Impacts from California Phase 2 Reformulated Gasoline and Related Clean Fuels Refinery Modifications: Appendix N," January 2003; California total gasoline production from EIA data.
- (2) Capital investment data from testimony of FTC technical expert Michael Sarna, Trial Transcript, *In the Matter of Union Oil Company of California*, Docket No. 9305, December 20, 2004 at 6189 discussing RX-1154-027 (Expert Report of Michael E. Sarna at 27).
- (3) CARB annualizing methodology applied to actual investment data. Annualizing coefficient for capital from large refiner, 10-year capital recovery scenario equation in CARB Proposed Regulations for California Phase 2 Reformulated Gasoline, Technical Support Document, Table VI-5, p. 134.

patent holder's bargaining skill is weak or the technology's inherent advantage caused *ex ante* power $MP_A > 0$. In our numerical example, recall that *ex ante*, with a production cost of \$40 using the patented technology and \$50 using the alternative, users were willing to pay up to \$10 to use the patented technology. After spending \$25 to implement the patented technology, the *ex post* cost to switch to the alternative was \$35, comprised of the \$10 inherent advantage plus the \$25 sunk investment in the patented technology. This measures the patented technology's full *ex post* advantage, or the *sum* of hold-up power *plus* its inherent advantage.

G. HOLD-UP POWER IS NOT A GOOD FIX FOR UNDER-REWARDED INNOVATION

As we discussed above, *ex ante* the technology user and the patent holder will not negotiate a royalty above the technology's inherent advantage of \$10 in our example. Depending on their relative bargaining power, they may negotiate a significantly lower royalty, so *ex ante* market power MP_p will be strictly below the technology's inherent advantage V_A . Would this imply that the patent is "under-rewarded" and that hold-up should be allowed, so as to raise the patent holder's reward and perhaps bring it closer to \$10? That is, should we ask whether MP_p is closer to V_A than is MP_A ?⁶⁷ For a number of reasons, our answer is "no."

First, innovation incentives and innovative contributions are *not* generally aligned by giving a patent holder a payment approaching 100 percent of the patented technology's inherent advantage. That would be the case only if the alternative to this inventor making the discovery were that it would never be found. In fact, many patented inventions are "in the air" and would be found soon in any case, so the reward that aligns incentives is only the social value of having the invention a bit sooner, typically a relatively modest proportion of the patented technology's inherent value.⁶⁸ Indeed, if the SSO picks the technology without its being suggested by the patent holder, a strict causation analysis would say that the patent holder contributed nothing to the innovation's availability in this use.⁶⁹

Second, when multiple firms engage in complementary innovation, it is not possible (without subsidies from outside) for each innovator's reward to equal its invention's incremental contribution: the sum of values of the incremental contributions exceeds the total value. Thus, suppose that the user in our example also engaged in innovation, leading to a product worth \$100. If the user adopts the patented technology, this product can be produced at a cost of \$40, so the net value of both innovations together is \$60. As already discussed, the patented technology's

⁶⁷ Note that with $MP_p \geq MP_A$, a sufficient condition would be $MP_p \leq V_A$, which is the condition that, if faced with a take-it-or-leave-it royalty proposal of MP_p *ex ante*, the SSO would have accepted rather than rejected. That is, should we ask whether the patent holder's royalty demands would have been "acceptable" *ex ante* to the SSO?

⁶⁸ See, e.g., HAL R. VARIAN ET AL., THE ECONOMICS OF INFORMATION TECHNOLOGY 68 (2004); see also Shapiro, *Aligning Reward and Contribution*, *supra* note 31, at 177–78.

⁶⁹ The fact that the SSO came up with the technology without seeing it disclosed in the patent is surely, from a Bayesian if not a legal point of view, evidence that the invention is fairly obvious to one skilled in the art, and from an economic point of view evidence that the patent holder's incremental contribution was small. This relates to the logic of independent inventor defenses in patent policy. See, e.g., Shapiro, *Aligning Reward and Contribution*, *supra* note 31, at 193–203.

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incremental contribution is \$10. But the technology would have no value (here) without the complementary product innovation, whose incremental contribution is therefore \$60. Consumers will not pay more than \$100, and \$40 is spent on production costs; thus, without a subsidy, it is not possible for the user and the patent holder both to capture their incremental contribution. If the patent holder captures 100 percent of its contribution, i.e., \$10, the user will capture less than its contribution.

Third, a key advantage of the patent system as an innovation incentive scheme is that it tailors rewards to the contribution, unlike (say) a scheme awarding \$100,000 to every inventor who convinced a Prize Transfer Office that he had found a useful and non-obvious invention. Many patented inventions are almost worthless, while some are very valuable, and rewards should be aligned with (but not in general exhaust) the invention's inherent advantage, an alignment that the patent system broadly achieves. If patent holders have too little bargaining skill, and therefore earn inefficiently low royalties, it might be beneficial to extend patent lifetimes or seek other ways to allow patent holders to capture a higher fraction of their innovations' inherent value. In contrast, the hold-up-based increment will not tend to be much correlated with any such shortfall of private return. Rather, the increment depends on such matters as the timing and specificity of user investments. Among other problems, returns based on hold-up would not address any shortfall to innovators that cannot or do not hold up technology users.

Fourth, while allowing a particular patent holder to engage in hold-up gives that patent holder an extra reward *ex post*, it does not follow that allowing hold-up generally increases rewards to inventors, or even that it rewards this inventor more *ex ante*. Because it is likely to sharpen vested interest and thereby increase suspicion in the standards process, allowing hold-up is likely to encourage SSOs to avoid potentially patented technologies altogether, or to worsen standard-setting delays to a degree that may well *lower* the overall return to patented inventions.⁷⁰

Fifth, beyond the conventional deadweight loss of higher *ex post* royalties, allowing hold-up is a costly way to provide rents to patent holders. For instance, users fearing patent ambush would have an incentive to inefficiently delay specific investments or postpone introducing new products, or to insist on *ex ante* negotiation even where it is highly inefficient, or to avoid using the best technology because it might be patented.

⁷⁰ Joseph Farrell & Tim Simcoe, *Choosing the Rules for Formal Standardization* 21 (Working Paper, Jan. 2007), available at <http://www.rotman.utoronto.ca/timothy.simcoe/papers/formal.pdf>.

This economic reasoning resonates with important strands of established public policy in intellectual property and antitrust law. Many would say that the royalties the patent holder would negotiate *ex ante* with users of its technology reflect the rewards normally and properly due to the patent holder. We take the position that royalties that are or would be negotiated *ex ante* with full information are a market benchmark reflecting legitimate return to innovation, but royalties in excess of this level may reflect unjustified market power, especially if achieved through conduct that is otherwise undesirable.

III. SSO PATENT RULES

Many SSOs have rules that bear on patent hold-up. Lemley characterizes the considerable diversity among SSO rules as "accidental."⁷¹ Subsequent work seeks to explain it in terms of a policy tradeoff for an SSO: stronger rules mitigate the hold-up problem, but could cause some patent holders not to join the SSO.⁷² Lerner and Tirole develop a theory relating SSO membership to SSO rules; Chiao, Lerner, and Tirole characterize SSOs based on orientation toward technology sponsors or users, and explore how disclosure and licensing policies relate to each other and to such orientation.⁷³ We discuss three types of SSO rules: disclosure rules, negotiation rules, and licensing rules. Broadly, disclosure rules seek to eliminate pure hold-up and allow SSO members to judge for themselves whether other protections will adequately limit hold-up in a particular case; negotiation rules could help make negotiations better reflect *ex ante* competition, but overblown concerns about collective negotiation weaken this approach;⁷⁴ and licensing rules are best seen as an imprecise but binding default *ex ante* contract.

A. DISCLOSURE RULES

Patent hold-up often arises when participants learn too late about patents essential to the standard. An SSO can, thus, seek to limit patent hold-up by requiring participants to disclose patents in the standard-setting process.

⁷¹ Lemley, *Intellectual Property Rights*, *supra* note 24, at 1895.

⁷² For instance, it has been suggested that Rambus quit JEDEC in order to avoid its disclosure requirements. In its Complaint, Commission staff alleged that Rambus resigned from JEDEC shortly after learning about the Commission's settlement in the *Dell* matter and on the advice of Rambus's outside counsel that the company should end "further participation in any standards body." *Rambus Inc.*, Opinion of the Commission, *supra* note 10, ¶ 81.

⁷³ Josh Lerner & Jean Tirole, *A Model of Forum Shopping*, 96 AM. ECON. REV. 1091, 1107 (2006); Chiao et al., *supra* note 29, at 1–2.

⁷⁴ See *infra* Part III.B.2.

Many situations of standard setting "hold up" can be mitigated by disclosure in the *ex ante* phase, before the standard is set. For example, if all participants are required to disclose their financial interest in any version of the standard—including any patents they own or are seeking on the technology—other participants can adjust their behavior accordingly.⁷⁵

Disclosure rules vary in their scope, timing, enforcement, and limitations.

1. Scope of Disclosure Rules

The scope of disclosure rules has several aspects. For example, rules increasingly specify that patent applications, as well as issued patents, must be disclosed. JEDEC requires that ballots used in voting during deliberations over standards be printed with a request for disclosure of "any patents (granted or pending),"⁷⁶ and the European Telecommunications Standards Institute (ETSI) defines intellectual property covered by its policy to include patent applications.⁷⁷ The World Wide Web Consortium (W3C) requires disclosure of published patent applications, including any unpublished claims that are essential to a standard; W3C requires disclosure of unpublished patent applications only when the application's claims are based on information obtained from a W3C working group or document.⁷⁸ ITU requires disclosure of essential patents and patent applications.⁷⁹

Typically, SSO rules do not require patent holders to state *ex ante* the terms on which they will license their patents, including the royalty rates they will offer. However, the new patent policy adopted by the VMEbus International Trade Association (VITA) requires participants to disclose

⁷⁵ R. Hewitt Pate, Ass't Att'y Gen. for Antitrust, U.S. Dep't of Justice, EU Competition Workshop, Competition and Intellectual Property in the US: Licensing Freedom and the Limits of Antitrust 9 (June 3, 2005), available at <http://www.usdoj.gov/atr/public/specches/209359.pdf>.

⁷⁶ JEDEC SOLID STATE TECH. ASS'N, JEDEC MANUAL OF ORGANIZATION AND PROCEDURE, JM21-L § 5.1 (2002) [hereinafter JEDEC MANUAL], available at <http://www.jedec.org/Home/manuals/JM21M.pdf>.

⁷⁷ EUR. TELECOMM. STANDARDS INST., ETSI INTELLECTUAL PROPERTY RIGHTS POLICY § 15.7 (2007) (on file with authors) [hereinafter ETSI IPR POLICY].

⁷⁸ W3C, W3C PATENT POLICY §§ 3.1, 8.1 (2004), <http://www.w3.org/Consortium/Patent-Policy-20040205/>.

⁷⁹ "Any party participating in the work of ITU, ISO or IEC should, from the outset, draw the attention of the Director of ITU-TSB, the Director of ITU-BR, or the offices of the CEOs of ISO or IEC, respectively, to any known patent or to any known pending patent application, either their own or of other organizations. . . ." ITU TELECOMM. UNION, COMMON PATENT POLICY FOR ITU-T/ITU-R/ISO/IEC § 1 (2005), <http://www.itu.int/ITU-T/dbase/patent/patent-policy.html>. Note that ITU requires disclosure from any one with knowledge of a patent, not just the patent holder. *Id.*

not only their patents but also any especially restrictive license terms they will offer.⁸⁰

Few SSOs require a member to search its portfolio for relevant patents. VITA now requires participants to make "a good faith and reasonable inquiry into the patents and patent applications the VITA Member Company (or its Affiliates) owns, controls or licenses."⁸¹ Participants are not required to search their entire patent portfolios, but can satisfy the good faith obligation by discussing the draft standard with the relevant technical and legal experts at their company.⁸² But ANSI and ETSI, among others, explicitly disavow any search requirement.⁸³ With over 150,000 U.S. patents granted annually,⁸⁴ even patent holders (or at least their representatives at SSOs) may not know what patents they have.⁸⁵ While the costs of search are real, a patent holder seems likely to have a comparative advantage in evaluating its patent portfolio. If search is burdensome for the patent holder, it is presumably equally or more burdensome for potential infringers.

⁸⁰ The VITA Standards Organization is the standard-setting arm of VITA, a non-profit entity concerned with real-time, embedded computer systems. The new VITA patent policy was approved by VSO members in January 2007. *See* VITA STANDARDS Org., VITA PATENT Policy (Dec. 2006) [hereinafter VITA Patent Policy], available at <http://www.vita.com/disclosure/VITA%20Patent%20Policy%20section%2010%20draft.pdf>. ANSI determined that the new policy is consistent with ANSI's patent policy in May 2007 and reaffirmed this decision in October 2007. Matrox is appealing ANSI's decision. *See* VITA, Disclosure and Licensing of Patents in Standards, <http://www.vita.com/disclosure>.

⁸¹ *Id.* § 10.2.1.

⁸² VITA, Implementation Plan for VITA's Revised Patent Policy 2, <http://www.vita.com/disclosure/implementation-ex-ante.pdf>.

⁸³ AM. NAT'L STANDARDS INST., GUIDELINES FOR IMPLEMENTATION OF THE ANSI PATENT POLICY § III.A (2003) [hereinafter ANSI GUIDELINES], available at <http://public.ansi.org/ansionline/Documents/Standards%20Activities/American%20National%20Standards/Procedures,%20Guides,%20and%20Forms/PATPOL.DOC>; ETSI IPR Policy, *supra* note 77, § 4.2. ETSI's policy that members are not required to perform patent searches is addressed at length in the ETSI IPR Policy. ETSI will, however, perform patent searches at the request of the EC or EFTA. *Id.* § 6.8.

⁸⁴ 2005 U.S. PATENT & TRADEMARK OFFICE, PERFORMANCE AND ACCOUNTABILITY FISCAL YEAR ANNUAL REPORT 18, 123, tab. 6, available at <http://www.uspto.gov/web/offices/com/annual/2005/2005annualreport.pdf>.

⁸⁵ A Texas Instruments representative testified: "It has something like 8,000 patents in the United States that are active patents, and for us to know what's in that portfolio, we think, is just a mind-boggling, budget-busting exercise to try to figure that out with any degree of accuracy at all." Competition and Intellectual Property Law in the Knowledge-Based Economy, or, at 749 (FTC/DOJ Hearings, Feb. 26, 2002), available at <http://www.ftc.gov/opp/intellect/020229ftc.pdf>. Apparently not all firms share this concern. Research in Motion informed ETSI that "There is no undue burden to ask for disclosure. All major companies and even small companies track their IPR very closely and would have no real problem disclosing or at least agreeing to license in a general statement. Every company that attends a standards meeting is reviewing IPR. It has been a race to do this in standards for a decade." Research in Motion, Intellectual Property Rights Policies, GSC10/IPRWG(05)16 (Aug. 29, 2005) (on file with authors).

Typically, only patents that are “essential” need be disclosed.⁸⁶ In defining “essential,” the Institute of Electrical and Electronics Engineers (IEEE) describes “essential patents” as necessarily infringed by “either mandatory or optional portions” of the standard.⁸⁷ That is, the patent is considered essential if one cannot implement the entire standard without infringing, even if parts of the standard can be implemented without so doing.

2. Timing of Disclosure

SSO policies generally stress “early disclosure” but seldom make precise what constitutes “early.” The European Commission’s DG Comp recently pressed ETSI to clarify the meaning of “timely” in its disclosure rules, stating that it is crucial “that standard-setting bodies establish rules which ensure fair, transparent procedures and the early disclosure of relevant intellectual property.”⁸⁸ Some put the issue of patent disclosure in front of participants repeatedly. IEEE, for example, requires patent holders to make assurances regarding willingness to license “as soon as reasonably feasible” but “no later than the approval of the standard.”⁸⁹ IEEE further instructs chairmen of its Working Groups to remind the participants of IEEE’s patent policy at each meeting and give them an

⁸⁶ The ITU patent policy statement in *GUIDELINES FOR IMPLEMENTATION OF ITU-T PATENT POLICY*, for example, concerns patents or patent applications “whose use would be required to implement ITU-T Recommendation(s).” ITU TELECOMM. STANDARDIZATION SECTOR, *GUIDELINES FOR IMPLEMENTATION OF ITU-T PATENT POLICY 3*, § 2. (2005), <http://www.itu.int/ITU-T/dbase/patent/files/glp20051102.pdf>. See also INST. OF ELEC. AND ELEC. ENG.’S STANDARD ASS’N, IEEE-SA STANDARDS BOARD BYLAWS, SECTION 6: PATENTS § 6.1 (2006) (defining “essential”) [hereinafter IEEE-SA BYLAWS], available at <http://standards.ieee.org/guides/bylaws/sect6-7.html>; ETSI IPR POLICY, *supra* note 77, § 15.6 (defining essentiality on technical grounds, not commercial ones).

⁸⁷ IEEE-SA BYLAWS, *supra* note 86, § 6.1.

⁸⁸ Press Release, European Commission, Competition: Commission Welcomes Changes in ETSI IPR Rules to Prevent “Patent Ambush” (Dec. 12, 2005), available at <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/05/1565&type=HTML&aged=0&language=EN&guiLanguage=EN>. See also Memorandum to the ETSI Gen. Assemb. attaching Letter from Eur. Comm’n Information, Communic’n and Multimedia Dir. to Karl Heinz Rosenbrock, ETSI Director General ETSI/GA#44(04)41, at 3 (Nov. 29, 2004) (on file with authors) (describing concerns about the “absolute discretion in the interpretation of the word ‘timely’ in ETSI’s IPR rules”). Following meetings and correspondence with the European Commission’s Competition Directorate General, 46th ETSI General Assembly approved changes to the IPR policy in November 2005. Memorandum from ETSI, Revision 1 Summarizing Minutes, Decisions and Actions from the 46th ETSI General Assembly Meeting, GA46(05)36, at 19 (Mar. 6, 2006) (on file with authors).

⁸⁹ IEEE-SA BYLAWS, *supra* note 86, § 6.2.

opportunity to disclose essential patents.⁹⁰ As mentioned above, JEDEC ballots are printed with a disclosure request.⁹¹

Costs may well begin to be sunk and partial commitments made long before a standard is formally adopted, so disclosure only when a standard is up for a vote may be much too late. Yet, at earlier stages an SSO may be considering many technologies, some rather informally, so full disclosure is an ambitious goal; indeed, information overload might well result from any attempt to disclose "fully."⁹²

3. Enforcement of Disclosure Rules

When standards with unanticipated patents get adopted, SSOs may attempt damage control and/or sanctions. VITA's new patent policy establishes an arbitration board to handle allegations of non-compliance, and provides that if members of its standards development committee do not "adequately and timely disclose" essential patents, then those patents must be licensed royalty-free.⁹³ ETSI provides that members who intentionally delay patent disclosure are subject to sanctions determined by the ETSI General Assembly.⁹⁴

Perhaps more typically, JEDEC's policy requiring royalty-free or RAND licenses "applies with equal force" if a patent is not issued or discovered to be applicable until after a standard is finalized.⁹⁵ IEEE and ANSI have similar requirements.⁹⁶ ETSI requests that the patent holder

⁹⁰ INST. OF ELEC. AND ELEC. ENG'RS STANDARD ASS'N, INSTRUCTIONS FOR THE WG CHAIR 1 (May 1, 2007), available at <http://standards.ieee.org/board/pat/pat-slideset.ppt>.

⁹¹ JEDEC MANUAL, *supra* note 76, § 5.1.

⁹² For example, Qualcomm reported that during the period while 3G standards were being developed, roughly 2,000 technical contributions regarding the radio access network, each with potentially different essential IPR, were offered every three months. Further, "[t]o assess an IPR portfolio in connection with each such contribution would require resources and effort that would be entirely unreasonable." Memorandum to ETSI Enclosing Comments on Proposals for Changes to IPR Policy from Qualcomm Europe S.A.R.L. 2 (Mar. 22, 2006) (on file with authors).

⁹³ VITA PATENT POLICY, *supra* note 80, § 10.4.

⁹⁴ ETSI IPR POLICY, *supra* note 77, § 14.

⁹⁵ JEDEC MANUAL, *supra* note 76, at 27, Annex B.3.

⁹⁶ IEEE imposes an ongoing obligation on participants to submit updated or additional Letters of Assurance regarding their patent licensing position upon learning that any patent claims are or may become essential to a standard. IEEE-SA BYLAWS, *supra* note 86, 6.2. ANSI's Guidelines for implementation of its policy indicate that when an applicable patent issues or is discovered after a standard is adopted, "the holder is obligated to provide the same assurances to ANSI as are required in situations where patents exist or are known prior to approval of a proposed standard as an American National Standard." ANSI GUIDELINES, *supra* note 83, § III.C.

make the patent available on FRAND licensing terms and if the patent holder is unwilling to do so, ETSI may suspend work on the standard.⁹⁷

Rambus suggested treating this not as a fallback policy should disclosure fail, but as an alternative to a disclosure requirement. That is, it suggested that SSOs could adopt a blanket FRAND policy under which members need not disclose their patents or patent applications provided they promise to offer FRAND terms on any of their patents that end up being included in a standard.⁹⁸ While we have stressed that ex ante negotiation is problematic, that is not a good reason to allow patent holders to deny other SSO participants the chance to try. Eliminating disclosure duties gives up on ex ante negotiation and replaces it with the difficult ex post task of determining a "fair and reasonable" royalty.

4. Limitations of Disclosure Rules

Early disclosure, promptly followed by well-informed ex ante negotiation, is intellectually the cleanest and most targeted response to the problem of patent hold-up, and we favor policies that minimize barriers to this approach. Rather than reconstruct later, in court, after costs are sunk and alternatives have grown stale, what licensing terms would have been negotiated ex ante, when feasible it seems far preferable for the parties to negotiate before the standard is set.

Disclosure even of an issued patent, let alone of an application, does not clearly reveal what will eventually be held to be covered by a valid patent. This patent fog stems from various aspects of patent policy, including: the secrecy of patent applications;⁹⁹ willfulness rules that encourage potential infringers *not to read* issued patents;¹⁰⁰ the difficulty of patent claims interpretation; patent applicants' ability to amend their claims (apparently even to cover a competitor's product that previously was not plainly covered);¹⁰¹ and the fact that many issued patents are invalid, but their invalidity may emerge only after prolonged and costly litigation that users may have little individual incentive to pursue.¹⁰²

⁹⁷ ETSI IPR Policy, *supra* note 77, § 6.

⁹⁸ Brief of Appellee and Cross-Appellant Rambus Inc. at 102, Rambus Inc., FTC Docket No. 9302 (June 2, 2004).

⁹⁹ Until December 2000, applications for U.S. patents were secret until a patent issued. Since then, U.S. applications that are also filed abroad are secret only for 18 months from the filing or priority date.

¹⁰⁰ See Lemley, *Intellectual Property Rights*, *supra* note 24, at 1959 n.292.

¹⁰¹ Cf. *Kingsdown Med. Consultants v. Hollister Inc.*, 863 F.2d 867, 877 (Fed. Cir. 1988) (en banc).

¹⁰² See Joseph Scott Miller, *Standard Setting, Patents, and Access Lock-In: RAND Licensing and the Theory of the Firm*, 40 IND. L. REV. 351, 372–73 (2007); Joseph Farrell & Robert P. Merges, *Incentives to Challenge and Defend Patents: Why Litigation Won't Reliably Fix Patent*

Furthermore, enforcing effective disclosure even on members is hard, and SSOs cannot privately enforce disclosure on non-members. Moreover, as discussed below, even following disclosure, effective *ex ante* negotiation is generally difficult when, as here, property rights are only vaguely defined, and when there are multiple highly interested parties with divergent interests and highly imperfect information about their alternatives.¹⁰³ So, while *ex ante* negotiation following disclosure is a good solution in principle, it is not a complete solution.

Consequently, there is a benefit from institutions that allow SSOs to postpone negotiation without permitting hold-up. SSO licensing rules, discussed below, might, thus, be seen as paralleling provisions in the Uniform Commercial Code (UCC) for interpretation and enforcement of buyer-seller contracts that do not specify a price.¹⁰⁴

B. NEGOTIATION RULES

SSO rules are seldom explicit about royalty negotiation practices. Two main questions arise: (1) whether negotiation is *ex ante* or *ex post*, and (2) whether negotiations are collective or decentralized.

1. Facilitating *Ex Ante* Negotiations

While we see no policy objections to *ex ante* negotiation as such,¹⁰⁵ *ex ante* negotiations appear to be relatively difficult and

Office Errors and Why Administrative Patent Review Might Help, 19 BERKELEY TECH. L.J. 943, 954–55 (2004); Lemley & Shapiro, *Probabilistic Patents*, *supra* note 54, at 88–90; Farrell & Shapiro, *supra* note 54, at 8.

¹⁰³ Bessen and Meurer argue that the core failing of intellectual property policy is that rights are unclear. JAMES BESEN & MICHAEL MEURER, INNOVATION AT RISK (forthcoming 2007) (manuscript at 12, on file with authors).

¹⁰⁴ The UCC holds that a valid and enforceable contract can exist even if no price is specified, provided that the parties intended to make a contract for sale. In these cases, “the price is a reasonable price at the time for delivery” of the goods. U.C.C. § 2-305 (1998).

¹⁰⁵ Concerns about *ex ante* negotiation based on the *Sony Electronics v. Soundview Technologies* case that were expressed in the speech by Hew Pate appear to be about collective negotiation, not *ex ante* negotiation as such. See Pate, *supra* note 75, at 9. In that case, a federal government regulation mandated the installation of V-chip technology in televisions manufactured after a certain date. A subcommittee of the Electronics Industry Association (EIA) convened to examine patents that might read on V-chip technology determined that six patents, including one held by Soundview, were essential. Soundview declared its intention to license the patents on non-exclusive and non-discriminatory terms. Soundview alleged that television manufacturing participants in EIA collectively decided to limit the amount they would pay to Soundview and to engage in a group boycott. The actions alleged to be harmful occurred after a standard had been set (by virtue of the government regulation). *Sony Elecs., Inc. v. Soundview Techs., Inc.*, 157 F. Supp. 2d 189, 181 (D. Conn. 2001); see also Masoudi, *supra* note 52, at 9–10. In addition, the DOJ and FTC recently opined that “[b]ecause of the strong potential for procompeti-

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rare.¹⁰⁶ Few SSOs actively promote or require ex ante negotiations; many SSOs regard their activities as technical, not commercial, and typically involve engineers not responsible for negotiating patent licenses. As discussed below, SSOs have historically been fearful of the possible antitrust implications of housing royalty negotiations. Perhaps as a result, for example, ETSI explicitly prohibits licensing negotiations from taking place under its auspices:

Specific licensing terms and negotiations are commercial issues between the companies and shall not be addressed within ETSI. Technical Bodies are not the appropriate place to discuss IPR Issues. Technical Bodies do not have the competence to deal with commercial issues. Members attending ETSI Technical Bodies are often technical experts who do not have legal or business responsibilities with regard to licensing issues. Discussion on licensing issues among competitors in a standards making process can significantly complicate, delay or derail this process.¹⁰⁷

VITA's patent policy, like ETSI's, prohibits license negotiations among members at standards meetings, but it requires that members holding patents announce their maximum royalty rate and their most restrictive non-royalty licensing terms.¹⁰⁸ VITA further encourages members to disclose complete draft licensing terms, and if no such draft is offered, prohibits the patent holder from requiring grantbacks or other provisions more restrictive than VITA's model licensing guidelines.¹⁰⁹ The DOJ has concluded that VITA's policy "should preserve, not restrict, competition among patent holders."¹¹⁰

tive benefits, the Agencies will evaluate joint ex ante activity to establish licensing terms under the rule of reason." U.S. DEPT' OF JUSTICE & FED. TRADE COMM'N, ANTITRUST ENFORCEMENT AND INTELLECTUAL PROPERTY RIGHTS: PROMOTING INNOVATION AND COMPETITION 54 (2007), available at <http://www.ftc.gov/reports/innovation/P040101PromotingInnovationandCompetition rpt0704.pdf>.

¹⁰⁶ Rambus argued that ex ante negotiations over its patent applications would have been "all but impossible," but the FTC rejected that notion, partly on evidence that Rambus had successfully negotiated licenses for its RDRAM patents before they issued. *Rambus, Inc.*, Opinion of the Commission, *supra* note 10, at 97–98 n.543.

¹⁰⁷ EUR. TELECOMM. STANDARDS INST., ETSI GUIDE ON INTELLECTUAL PROPERTY RIGHTS, 14 (Jan. 2007), available at http://www.etsi.org/Websit/document/Legal/ETSI_Guide_on_IPRs.pdf.

¹⁰⁸ VITA PATENT POLICY, *supra* note 80, § 10.3.4; Business Review Letter from Thomas O. Barnett, Ass't Att'y Gen., U.S. Dep't of Justice, to Robert A. Skitol, Drinkler, Biddle & Reath, LLP 9 (Oct. 30, 2006) [hereinafter Barnett Oct. 30, 2006 Skitol Business Review Letter], available at <http://www.usdoj.gov/atr/public/busreview/219380.pdf>.

¹⁰⁹ VITA PATENT POLICY, *supra* note 80, § 10.3.2.

¹¹⁰ Barnett Oct. 30, 2006 Skitol Business Review Letter, *supra* note 108, at 10.

2. *Collective vs. Decentralized Negotiations*

When network effects are important (as a strong role for an SSO suggests), the technology adoption decision is in reality collective. One way or another, the market will tip, and an individual user can hardly decide unilaterally to avoid a technology that is essential to a standard to which it expects others to conform. At a general level, therefore, decentralized or bilateral (patent holder/user) negotiations do not fit well with the mechanisms by which standards are chosen. This suggests a sympathetic attitude—within limits—to collective negotiation, which has a better fit with technology choice mechanisms than do bilateral negotiations.

The classic danger associated with collective negotiation is that, in order to depress prices, buyers collectively (facing an upward-sloping supply curve) will choose a smaller quantity than would be efficient or than they would individually. That classic monopsony concern is absent here: there is no upward-sloping supply curve where the supplier is providing intellectual property.¹¹¹ Instead, the quantity effect would be driven by demand: a lower royalty rate will (ex post efficiently) increase sales of products complying with the standard.

The potential danger, instead, is that by negotiating as a group, technology users could extract such favorable terms from patent holders (another form of hold-up) that they will inefficiently discourage future innovation.¹¹² While this danger is no greater for SSOs than in other situations where an innovator negotiates with a single large user, antitrust law typically treats such collective bargaining with suspicion.¹¹³ For example, one might ask whether members of the SSO would be viewed

¹¹¹ Our claim that the supply of IP is elastic relies on the mild assumption that the licensing fees paid by each licensee are sufficient to cover the transaction costs borne by the patent holder from licensing to that licensee.

¹¹² These arguments were made in *Sony Electronics, Inc. v. Soundview Technologies, Inc.*, 157 F. Supp. 2d 180, 185 (D. Conn. 2003). Soundview alleged that participants in an EIA subcommittee had agreed to limit the price they would pay for a V-chip patent necessary to comply with a government regulation. Sony argued that such an outcome would not harm competition because consumers would pay less as a result. But Soundview also contended that there was harm in a technology market since a joint action to lower patent prices would inefficiently discourage innovation. Sony replied that the theory was economically irrational because Sony, as a purchaser of patented technologies, would find it in its interest to encourage innovation, not discourage it. The court held that Soundview had sufficiently alleged a monopsony conspiracy to satisfy the required elements of an antitrust claim. *Id.* at 182, 190.

¹¹³ However, in many cases, the technology providers are integrated into production and thus enjoy ancillary benefits from their research and development activities, apart from royalty income from other members of the SSO, such as know-how that allows them to add valuable but optional features to the product or an ability to manufacture the standardized products at low cost. Referring to the concern that collective ex ante negotiations may discourage R&D, FTC Chairman Majoras stated in her September 23, 2005,

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as engaging in a group boycott if they collectively chose not to adopt the patent holder's technology.¹¹⁴ The FTC studied this issue in the hearings that led to its 2003 report.¹¹⁵ Witnesses emphasized how *ex ante* negotiations can prevent hold-up.¹¹⁶ It would be ironic and counter-productive if antitrust concerns obstructed procompetitive collective *ex ante* negotiations. This position has recently been endorsed by leaders at both the Antitrust Division and the FTC. FTC Chairman Deborah Majoras has made clear her view that competition is promoted by avoiding hold-up, and that collective *ex ante* negotiations can often serve this purpose.¹¹⁷ As then-Assistant Attorney General Pate noted:

It would be useful to clarify the legal status of *ex ante* negotiations over price. Some standards development organizations have reported to the Department of Justice that they currently avoid any discussion of actual royalty rates, due in part to fear of antitrust liability. It would be a strange result if antitrust policy is being used to prevent price competition. There is a possibility of anticompetitive effects from *ex ante* license fee negotiations, but it seems only reasonable to balance that concern against the inefficiencies of *ex post* negotiations and licensing hold up.¹¹⁸

speech: "While theoretically possible, this risk is unlikely to be a frequent practical concern." Majoras, *supra* note 27, at 9.

¹¹⁴ See ABA STANDARDS-SETTING HANDBOOK, *supra* note 1, ch. 2. Addamax Corporation filed suit against the Open Software Foundation, for example, claiming that OSF had rigged the bidding process it used to choose a security software to be integrated with OSF's flavor of UNIX. Addamax Corp. v. Open Software Found., Inc., 868 F. Supp 274, 278 (1995). Addamax's product was not chosen, and although OSF members were free to purchase Addamax's product if they wished, they apparently did not do so, and Addamax soon withdrew its product from the market. Addamax Corp. v. Open Software Found., Inc., 132 F.3d 48, 50 (1st Cir. 1998). The merits of the case did not go to trial because the parties agreed that the question of whether Addamax was damaged would be settled first, and the court ruled that Addamax did not suffer damages due to OSF's actions. *Id.* at 51. Rather, Addamax's failure to succeed was due to factors like the company's late entry into a risky business that already housed strong competitors. *Id.*

In *Golden Bridge*, plaintiff alleged just such a group boycott. Golden Bridge Tech., Inc. v. Nokia, Inc., 416 F. Supp. 2d 525, 528 (E.D. Tex. 2006). In its denial of defendant's motion to dismiss, the court described the allegation as a "classic *per se* group boycott" in that Golden Bridge alleged joint efforts by SSO participants to refuse to deal with Golden Bridge, resulting in its being cut off from the market. *Id.* at 530. The court subsequently dismissed the complaint after the plaintiff failed to show a conspiracy among defendants. Golden Bridge Tech., Inc. v. Nokia, Inc., No. 6:06-CV-163, 2007 U.S. Dist. LEXIS 67071 at *22 (E.D. Tex. Sept. 11, 2007).

¹¹⁵ FED. TRADE COMM'N, *supra* note 53, at 3-4.

¹¹⁶ See generally DOJ/FTC IP Report 49-56 (2007); FTC/DOJ Hearings on Standard-Setting Organizations, *supra* note 29, at 42:25-73:10. Authors Farrell and Shapiro testified at the November 6, 2002, hearing.

¹¹⁷ See Majoras, *supra* note 27, at 7.

¹¹⁸ Pate, *supra* note 75, at 9.

The European Commission's Technology Transfer Guidelines similarly state:

Undertakings setting up a technology pool that is compatible with Article 81, and any industry standard that it may support, are normally free to negotiate and fix royalties for the technology package and each technology's share of the royalties either before or after the standard is set. Such agreement is inherent in the establishment of the standard or pool and cannot in itself be considered restrictive of competition and may in certain circumstances lead to more efficient outcomes. In certain circumstances it may be more efficient if the royalties are agreed before the standard is chosen and not after the standard is decided upon, to avoid that the choice of the standard confers a significant degree of market power on one or more essential technologies.¹¹⁹

Reviewing the VITA policy, the DOJ indicated that if VITA allowed joint negotiations of license terms, the DOJ would evaluate the policy under the rule of reason since there could be procompetitive benefits from such joint negotiations.¹²⁰ And the recently issued FTC/DOJ report on antitrust and intellectual property rights also emphasizes the procompetitive benefits of ex ante negotiations and indicates that such activity will be evaluated under the rule of reason.¹²¹

While collective choice better reflects standards demand, identifying the limits on permissible collective negotiations is difficult. One approach would be to permit the SSO to conduct an auction, under which patent owners bid for inclusion in the standard by indicating the terms

¹¹⁹ Guidelines on the Application of Article 81 of the EC Treaty to Technology Transfer Agreements (EC Apr. 27, 2004, 2004 O.J. (C 101) 1, 39.

¹²⁰ Barnett Oct. 30, 2006 Skitob Business Review Letter, *supra* note 108, at 9 n.27. The DOJ also recently reviewed a proposed IEEE patent policy that would allow, but not require, patent holders to commit to the most restrictive licensing terms, including maximum royalties, that they would offer on patents essential to an IEEE standard. Business Review Letter from Thomas O. Barnett, Ass't Attorney General, U.S. Dep't of Justice, to Michael A. Lindsay, Dorsey & Whitney 10 (Apr. 30, 2007), available at <http://www.usdoj.gov/atr/public/busreview/222978.pdf>. Although the proposed policy would prohibit joint negotiations on licensing terms at standards development meetings, current IEEE policy allows some discussion of the costs of implementing different standards. *Id.* at 8 n.37, 11. The DOJ stated that such discussions of costs "could, in certain circumstances, rise to the level of joint negotiation of licensing terms." *Id.* at 11. The IEEE had not requested that the DOJ comment on its views regarding joint negotiations, but the DOJ noted that it would typically apply a rule of reason analysis to the evaluation of joint negotiations in a standard setting body. *Id.* at 11 n.47; Barnett Oct. 30, 2006 Skitob Business Review Letter, *supra* note 108, at 8.

¹²¹ U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, ANTITRUST ENFORCEMENT AND INTELLECTUAL PROPERTY RIGHTS: PROMOTING INNOVATION AND COMPETITION 54 (2007), available at <http://www.usdoj.gov/atr/public/hearings/ip/222655.htm> [hereinafter ANTITRUST ENFORCEMENT AND IP].

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and conditions on which they will license their patents.¹²² This approach can harness the power of ex ante technology competition and might prevent the technology users from acting as a buyers' cartel, at least if the SSO is not permitted to impose a reserve price in the auction (here, a maximum royalty rate the SSO will accept). However, such an ex ante auction may not be practical. Back-and-forth bargaining between the SSO and patent holders may be necessary if, for example, the SSO is engaged in an ongoing process of evaluating technical alternatives, especially if the SSO or its members also are evaluating the scope and strength of the relevant pending or issued patents.

Another approach would be to permit members of an SSO collectively to negotiate royalties with patent holders, so long as membership in the SSO does not preclude any individual firm, or group of firms acting in concert, from producing competing products that do not comply with the standard. This approach recognizes the benefits of collective negotiation to prevent hold-up and subjects the SSO to rule of reason evaluation. Under this approach, a patent holder that does not like the terms being offered by the SSO can negotiate separately with one or more users to move forward with its own version of the product. However, the same network-effect logic that rationalizes joint negotiation also suggests that this safety valve may be relatively weak. These deep issues deserve further analysis.

C. LICENSING RULES

Of thirty-six SSOs with patent policies studied by Lemley, twenty-nine required members to license their patents on reasonable and nondiscriminatory terms, and another three requested but did not require that members do so.¹²³ We discuss separately the "fair and reasonable" part of FRAND and the "non-discriminatory" part.¹²⁴

¹²² Swanson and Baumol propose just such an ex ante auction model, shortly after stating that they "rule out defining a reasonable RAND royalty as the royalty that would be observed in the event that the prospective licensees were to band together (either before or after standard selection) and act as a buyer's cartel." Daniel G. Swanson & William J. Baumol, *Reasonable and Nondiscriminatory (RAND) Royalties, Standards Selection, and Control of Market Power*, 73 ANTITRUST L.J. 1, 13 (2005).

¹²³ See Lemley, *Intellectual Property Rights*, *supra* note 24, at 1906; Chiao et al., *supra* note 29, at 17–20, tbl. 2 (providing a more detailed analysis of patent policies among SSOs).

¹²⁴ We note that "fair and reasonable" terms are indicated in a range of contexts other than patent royalties. Federal procurement rules, for example, use "fair and reasonable" as a standard for appropriate pricing. See *Proposal Analysis Techniques*, 48 C.F.R. § 15.404-1 (2007); Federal Acquisition Institute, Unit 36: Price Analysis (Negotiated Acquisitions) (Oct. 2003), <http://www.fai.gov/pdfs/Unit36.pdf>.

1. Fair and Reasonable Royalties

Lemley observed that: "It is all well and good to propose that SSOs require licensing on reasonable and nondiscriminatory terms. But without some idea of what those terms are, reasonable and nondiscriminatory licensing loses much of its meaning."¹²⁵ And Assistant Attorney General Pate noted, "Increasingly, standards development organizations are requiring 'reasonable and non-discriminatory' (RAND) licensing, which is a partial solution. A difficulty of RAND, however, is that the parties tend to disagree later about what level of royalty rate is 'reasonable.'"¹²⁶ Thus, Broadcom alleged that Qualcomm used its RAND promise to induce various SSOs to adopt a UMTS standard on which Qualcomm claims many essential patents, but the parties disagree ex post about the meaning of the promise.¹²⁷ Indeed, few SSOs define the term "reasonable and nondiscriminatory" or have mechanisms to resolve disputes about its interpretation.¹²⁸

In the face of this difficulty, some courts, used to the idea that patent holders can generally set licensing terms as they please, appear to gravitate to the idea that a FRAND commitment means little or nothing. For instance, the *Townshend* court wrote: "Given that a patent holder is permitted under the antitrust laws to completely exclude others from practicing his or her technology, the Court finds that 3Com's submission of proposed licensing terms with which it was willing to license does not state a violation of the antitrust laws."¹²⁹ If this statement means that a patent holder may demand any royalty it wants ex post, such a view would gut FRAND as a protection against hold-up.¹³⁰ The district court in *Broadcom* court similarly argued that "Qualcomm's 'power' to control the licensing of its patents is derived from the rights it enjoys as a patent-holder. The adoption of an industry standard neither diminishes nor

¹²⁵ See Lemley, *Intellectual Property Rights*, *supra* note 24, at 1964.

¹²⁶ Pate, *supra* note 75, at 9.

¹²⁷ See *Broadcom* Complaint, *supra* note 18, ¶ 9 (alleging Qualcomm's failure to meet FRAND commitment).

¹²⁸ See Lemley, *Intellectual Property Rights*, *supra* note 24, at 1964–65.

¹²⁹ *Townshend v. Rockwell Int'l Corp.*, 55 U.S.P.Q.2d (BNA) 1011, 1018 (N.D. Cal. Mar. 28, 2000).

¹³⁰ Kattan suggests this interpretation of *Townshend*. Cf. Kattan, *supra* note 24, at 26–27. At the same time, *Townshend* may have been appropriately excused because it disclosed its proposed terms in advance. *Townshend*, 55 U.S.P.Q.2d at 1020. The court noted that "the ITU, whose members included Rockwell (Conexant's predecessor), adopted the V.90 standard after receiving 3Com's submission [licensing proposal]. The adoption of the V.90 standard by the ITU suggests that the ITU was satisfied that the proposed terms submitted by 3Com evidenced a willingness by 3Com to negotiate non-discriminatory, fair, and reasonable terms." *Id.* at 1018.

augments this exclusionary right.¹³¹ In a sense, indeed, Qualcomm's power rests on its patents, but that power may be greatly augmented by the adoption of the standard, as the Third Circuit emphasized in reversing the district court's decision.¹³² Moreover, while adoption of the standard *by itself* may not limit Qualcomm's right to exclude, Qualcomm's promise to license on FRAND terms surely does.¹³³

We start from the principle that FRAND rules should be interpreted as a mechanism by which SSO participants address the problem of patent hold-up when *ex ante* negotiation was absent or inconclusive, and by which they make efficient timing of negotiation possible without inviting hold-up. This implies that courts should interpret the fair and reasonable prong of FRAND as the royalties that would have been voluntarily negotiated before users became committed to using the patented technology.¹³⁴ As should be clear by now, this is typically *not* the same as the level of royalties that would be voluntarily negotiated *ex post*. Of course, a court-ordered solution is unlikely to be as sensitively structured to the needs of the parties as a negotiated solution can be, but this is simply an argument that parties should (and will) negotiate in the shadow of whatever the court would do. Many scholars accept this position,¹³⁵ but not all.¹³⁶

This view of FRAND assumes that the hold-up problem is a bigger concern than is the prospect of court errors in setting reasonable royal-

¹³¹ Broadcom Corp. v. Qualcomm Inc., 2006 U.S. Dist. LEXIS 62090, at *26 (D.N.J. Sept. 19, 2006) *aff'd in part, rev'd in part*, 501 F.3d 297 (3d Cir. 2007).

¹³² Broadcom Corp. v. Qualcomm Inc., 501 F.3d 297, 314 (3d Cir. 2007).

¹³³ *Id.* at 313.

¹³⁴ The precise interpretation is more complex because a particular user may be locked in by the network effects surrounding others' adoption even before it has itself made any investments. This interpretation of a "fair and reasonable" royalty differs from the *Georgia-Pacific* interpretation of "reasonable royalties" in a patent infringement case in at least two ways. First, the *Georgia-Pacific* notion presumes that the patent is valid as well as infringed. That assumption may not hold here, so some discounting is appropriate to reflect patent strength. *Georgia-Pacific Corp. v. U.S. Plywood Corp.*, 288 F.2d 124, 132–34 (2d Cir. 1968). Second, one of the *Georgia-Pacific* factors hypothesizes a negotiation between a patent holder that is willing to license and the infringer at the time that the infringement began. In the standard-setting context, the time when infringement actually begins is too late, because it is typically after a standard is set and investments have been made. See also VARIAN ET AL., *supra* note 68, at 81; SAVIRO & VARIAN, *supra* note 2, at 241.

¹³⁵ Cf. SWARZON & BAUMOL, *supra* note 122, at 27–28; see also ANNE LAURE-FARREAU ET AL., *Pricing Patents for Licensing in Standard-Setting Organizations: Making Sense of FRAND Commitments*, 74 ANTITRUST L.J. 671 (2007); RAMBUS INC., Remedy Opinion, *supra* note 16, at 17.

¹³⁶ Rambus's economic expert testified that Rambus would have given, and JEDEC would have accepted, a RAND promise, and the resulting royalty would be precisely what Rambus was then charging. Rambus Inc., FTC Docket No. 9302, Initial Decision at 320–21, 324–25, (Feb. 23, 2004) [hereinafter *Rambus Inc., Initial Decision*], available at <http://www.ftc.gov/os/adjpro/d9302/040223initialdecision.pdf>.

ties. In part, this reflects the observation that hold-up unambiguously biases the outcome upwards, while courts can err in both directions and it is only predictable (or the mathematical expectation of) court errors that will bias negotiations in the shadow of litigation. In part, it reflects a sense that, as discussed above, hold-up is apt to be a severe problem in SSO contexts.

2. Injunctions

Our interpretation implies that a patent holder that has made a commitment to license on a FRAND basis should not be able to get (or threaten) an injunction against use of the technology to comply with the standard.¹³⁷ An injunction would prevent a user from practicing the standard, whose value is by no means all attributable to this one patent holder's patents—because of specific investments by the user, because of innovations by the user, because of coordination, and because of the other inventions (patented or not) incorporated in the standard.¹³⁸ A patent holder that can credibly threaten an injunction can threaten to withdraw more surplus than its technology contributed.

3. Non-Discriminatory Royalties

SSOs seldom clarify what licensing structures would be non-discriminatory, nor do we know of useful legal holdings on this specific question. The typical definition of price discrimination is charging different prices to different customers for the same product (or different mark-ups for similar products). But defining what constitutes discriminatory licensing is not straightforward. There is no consensus, for example, about whether two-part tariffs discriminate against smaller licensees or whether royalties assessed as a percentage of the licensee's revenues discriminate against licensees who sell more expensive products. Furthermore, even determining whether different licensees are treated differently can be very difficult if cross-licenses are the norm.

Moreover, whereas we have identified an economically sound interpretation of the fair and reasonable prong of FRAND, which can guide its implementation, it is much less clear what social and private purposes the non-discriminatory prong of FRAND serves. Price discrimination can, in general, be a legitimate way for an inventor to extract value from

¹³⁷ See Lemley, *Intellectual Property Rights*, *supra* note 24, at 1932–33; Miller, *supra* note 102, at 358.

¹³⁸ See Shapiro, *Injunctions, Hold-Up and Patent Royalties*, *supra* note 56, at 1–4; Mark Lemley & Carl Shapiro, *Patent Hold-Up and Royalty Stacking*, 85 TEX. L. REV. 1991, 2025 (2007).

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its patent, and even holding aside innovation incentives, price discrimination is known, in general, to have ambiguous welfare effects. One might well ask how limiting discriminatory licensing helps with the hold-up problem or other problems arising in the standards context. We give one possible answer, then comment on three other ways in which non-discrimination policies might affect bargaining between patent holders and users.

a. Divide-and-Conquer Strategies

When network effects are important, a technology supplier may be able, even *ex ante*, to use divide-and-conquer negotiation strategies to extract more than the technology's true value V_A . The mechanism is much like that by which an incumbent might impose anticompetitive exclusive dealing on multiple customers when competitive entry requires many customers.¹³⁹ For instance, if there are three potential users, and network effects make it impossible for one to be viable without compatibility with the other two, a patent holder can offer two attractive licenses and one confiscatory one. But divide-and-conquer strategies are much less effective if the patent holder cannot discriminate.¹⁴⁰ Thus, non-discrimination provisions could help protect against divide-and-conquer overcharges. This is, in essence, the point that we noted above: the adoption decision is effectively collective, so bilateral negotiations involve a potentially problematic mismatch between choice and consequence. Non-discrimination rules can help bring the choice mechanism closer to one that responds to net value offered in the technology market.

b. Non-Discrimination and Pass-Through

A non-discrimination requirement may tend to make direct buyers lazy about *ex ante* negotiation and complacent about high (but uniform) marginal royalties that will be largely passed through to final users when direct buyers compete downstream. By making running royalties more uniform, non-discrimination rules could undermine *ex ante* negotiations and subvert direct buyers' role as guards against over-paying by downstream consumers.¹⁴¹

¹³⁹ Ilya Segal & Michael D. Whinston, *Naked Exclusion: Comment*, 90 AM. ECON. REV. 296, 296 (2000).

¹⁴⁰ Ilya Segal, *Coordination and Discrimination in Contracting with Externalities: Divide and Conquer?*, 113 J. ECON. THEORY 147 (2003). In some cases the ability to threaten discrimination is important even when the equilibrium does not display discrimination.

¹⁴¹ See *infra* Part IV; Teece & Sherry, *supra* note 24, at 1956–57; Farrell & Merges, *supra* note 102, at 954; Farrell & Shapiro, *supra* note 54, at 1.

Whereas divide-and-conquer concerns total charges to direct buyers, the pass-through issue (at least in the short to medium term) concerns running royalties. Thus, the structure of royalties affects these two issues differently. The interaction, when a patent holder seeks to divide and conquer direct buyers that compete downstream, is complex.¹⁴²

c. Cross-Licenses

A non-discrimination requirement might be interpreted as prohibiting the use of royalty-free cross-licenses between patent holders, perhaps on the grounds that such licenses enable patent-rich firms to favor one another and exclude patent-poor firms. Of course, whether such a cross-license is "discriminatory" would have to be assessed in light of the license value provided by the customer in return. As a policy matter, royalty-free cross-licenses may themselves be procompetitive, so a non-discrimination provision that limited their use might on balance be harmful.

d. Vertically Integrated Patent Holders

A non-discrimination requirement might be interpreted as preventing a vertically integrated patent holder from favoring its own downstream operations over its downstream rivals. This issue arises in *Broadcom*, where Qualcomm allegedly granted royalty discounts to handset licensees that agreed to purchase their chipsets from Qualcomm. Broadcom, a rival chipset manufacturer, claimed that these discounts violated Qualcomm's commitment to license on non-discriminatory terms and undermined Broadcom's ability to compete in the chipset market.¹⁴³

Swanson and Baumol describe such vertical concerns as the "principal justification for the RAND nondiscriminatory requirement,"¹⁴⁴ and advocate a pricing rule meant to ensure that a patent holder's fee to others is equal to what it charges itself for use of the patent. Because internal transfer prices are subject to manipulation, Swanson and Baumol propose that royalties consistent with the efficient component pricing rule (ECPR) be defined as non-discriminatory.¹⁴⁵ Under this rule, a royalty is discriminatory if it exceeds the difference between the patent holder's

¹⁴² Recent work on how the Segal & Whinston mechanism of divide-and-conquer changes when direct buyers compete downstream includes Chiara Fumagalli & Massimo Motta, *Exclusive Dealing and Entry, When Buyers Compete*, 96 AM. ECON. REV. 785 (2006); John Simpson & Abraham Wickelgren, *Naked Exclusion, Efficient Breach and Downstream Competition*, 97 AM. ECON. REV. 1395 (2007).

¹⁴³ *Broadcom* Complaint, *supra* note 18, at 5–6.

¹⁴⁴ Swanson & Baumol, *supra* note 122, at 27.

¹⁴⁵ See *id.* at 29.

price of the downstream good and its incremental cost of inputs other than the patent—in other words, if it would be losing money on its downstream production at the margin if it were charging itself what it charges others.¹⁴⁶

This is not the place for a full discussion of the ECPR test, but we note that an integrated firm with enough static market power downstream will often “falsely” pass this test without charging itself what it charges others. If the integrated firm makes a margin m on supplying an input to competitors, it will rationally behave as if it is charging itself the marginal cost of the input plus δm , where δ is the diversion ratio on downstream production, i.e., the (typically fractional) number of units by which competitors’ sales fall when the integrated firm sells one more unit. Effectively, when the firm sells one incremental unit, it suffers an opportunity cost of δm due to the lost margin on input sales to competitors. Thus when $\delta = 1$, the integrated firm will naturally charge itself what it charges rivals, and an ECPR test is unnecessary. On the other hand, when $\delta < 1$, its downstream division does not face (and does not act as if it faced) the same input cost as its rivals, and if that is an important policy goal, the ECPR test at least purports to address a real question. However, if the firm has enough downstream market power to price at least $(1 - \delta)m$ above its (resource plus opportunity) marginal cost, the ECPR test will not constrain the firm’s conduct, and the firm will pass the test. In other words, the ECPR test is prone to false negatives when $\delta < 1$ and the integrated firm faces less than perfectly elastic demand downstream; when downstream products are differentiated, both of those conditions will normally hold.

4. Many Essential Patents

When different parties own many essential patents covering a given standard, the hold-up problem may become more severe, and problems of complementarity arise. The hold-up problem gets worse because collectively the patent holders are apt to take a large proportion of incremental ex post surplus, so investments by technology users are subject to more severe expropriation ex post.¹⁴⁷ Complementarity problems arise both ex post and ex ante; the ex ante version implies additional FRAND constraints on ex post royalties.

Ex post, once the standard is selected, the essential patents must be used together to comply with the standard, and each patent holder ben-

¹⁴⁶ See *id.* at 28–30.

¹⁴⁷ For a discussion of Cournot complements in this context, see Lemley & Shapiro, *supra* note 136, at 2014, 2046–48.

efits if the royalties charged for the other essential patents are low. A "Cournot complements" problem ensues: the patent holders themselves collectively are better off if they can coordinate to charge an aggregate royalty that is *lower* than would arise from the uncoordinated setting of royalties.¹⁴⁸ This problem is not unique to standard setting; natural if imperfect solutions include cross-licenses and patent pools.¹⁴⁹

Ex ante, two patented technologies are technical complements as used in a proposed standard, if each one's inherent value (when used in the standard) is greater when the other is also used. With technical complements, however skillful the patent holders are at bargaining, ex ante technology competition would no longer allow each patent to receive its incremental value. This is because the sum of the incremental values of the two patents exceeds their value in combination. Thus, if each patent holder demanded its full incremental value, the two combined would lose out in ex ante competition against an alternative standard that infringes neither patent. This idea extends and is amplified if there are more than two separately owned patents.

As a result, under our guiding principle that the fair and reasonable prong of FRAND captures the royalties that the patent holder(s) could have negotiated ex ante given the alternatives available to the SSO, FRAND implies an additional constraint on royalties: the sum of the royalty rates for any group of essential patents cannot exceed the combined value of all of these patented technologies to the standard, measured in comparison with an alternative standard that infringes none of these patents. When the patented technologies are ex ante complements, this constraint is more stringent than the constraint that each patent holder cannot capture more than the incremental value of its patented technology, V_A , given the other technologies in the standard. It will then be important to consider all essential patents when establishing the fair and reasonable royalty for any one patent, and to have some mechanism to allocate the aggregate royalty among the patent owners. This is a difficult task that will not have an ideal solution, but allowing the Cournot complements and hold-up problems to run free is not ideal either.

¹⁴⁸ The Cournot complements problem can also arise in ex ante negotiations, and the constraint implied by FRAND discussed here also applies to ex ante royalties.

¹⁴⁹ For a discussion of problems that arise in the presence of many essential patents, along with some solutions, see Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools and Standard Setting*, in *INNOVATION POLICY AND THE ECONOMY* 119 (Adam Jaffe et al. eds., 2001). Patent pools are studied in Richard Gilbert, *Acknowledging Patent Pools: A Century of Policy Evolution*, 2004 STAN. TECH. L. REV. 3 (2004), http://www.law.berkeley.edu/institutes/bclt/stemcell/articles/gilbert_patent_pools.pdf; Josh Lerner & Jean Tirole, *Efficient Patent Pools*, 94 AM. ECON. REV. 691 (2004).

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Without reliable information about the relative importance of the various patents, a natural if imperfect default for an SSO to adopt for standards covered by large numbers of essential patents is to divide up the aggregate royalty by the number of essential patents. While this proportionality rule could in theory be highly imperfect, it is voluntarily used by a number of patent pools.¹⁵⁰ If such a proportionality rule were known to be the default method of apportioning royalties, a patent holder that believed that its patent portfolio was much more valuable than suggested by proportionality could make this assertion *ex ante*. Such a statement might itself trigger further useful *ex ante* discussion of the relative value of the different patent portfolios. More generally, the proportionality default could be modified, either *ex ante* or *ex post*, based on information about the *ex ante* incremental values of the essential patents. In any event, the proportionality default is only a backstop prescription, intended to provide guidance where information about relative values is lacking, in whose shadow one would hope and expect to find private negotiation.

¹⁵⁰ The MPEG2 patent pool allocates royalties in proportion to the patent holder's share of all the essential, pooled patents applicable in the country in which the product is made. The DOJ's business review letter regarding the MPEG patent pool structure does not comment specifically on the division of royalties, but notes that there was nothing in the patent pool agreements that would facilitate collusion or restrict innovation. Business Review Letter from Joel I. Klein, Acting Ass't Attorney General, U.S. Dep't of Justice, to Gerard R. Beebe, Sullivan & Cromwell 11-16 (June 26, 1997), available at <http://www.usdoj.gov/atr/public/busreview/215742.pdf> [hereinafter Klein June 26, 1997 Beebe Business Review Letter]. The DVD-6C patent pool began with a simple proportionality rule, but also provided for the introduction of an allocation based on, among other things, the age of a patent and whether it was essential to a mandatory or optional part of a standard. Business Review Letter from Joel I. Klein, Ass't Attorney General, U.S. Dep't of Justice, to Carey R. Ramos, Paul, Weiss, Rifkind, Wharton & Garrison 7 (June 10, 1999), available at <http://www.usdoj.gov/atr/public/busreview/2485.pdf> [hereinafter Klein June 10, 1999 Ramos Business Review Letter]. The 3GPP pool appears to use a proportionality rule and operates under "a principle of equal compensation for each essential patent." Business Review Letter from Charles A. James, Acting Ass't Attorney General, U.S. Dep't of Justice, to Ky P. Ewing, Vinson & Elkins, LLP 8 (Nov. 12, 2002), available at <http://www.usdoj.gov/atr/public/busreview/200455.pdf>. The European Commission discouraged ETSI from instituting a proportionality rule, however, on the basis that it would preclude price competition among alternative technologies since the price for any patent would be fixed in advance as a function of the total royalty cap and the number of essential patents. Letter from Angel Trujilco Cordero (Director DG Competition) to Karl Heinz Rosenbrock (Director General ETSI) re: ETSI IPR group discussions (June 21, 2006). For other examples of proportionality rules, see Reiko Aoki & Sadao Nagaoka, *Coalition Formation for a Consensus Standard Through a Standard Body and a Patent Pool: Theory and Evidence from MPEG2, DVD and 3G*, 2-4 at 19-20 (Hitotsubashi Univ. Inst. of Innovation Research, Working Paper WP05-01, 2005), available at http://www.ir.hit-u.ac.jp/file/WP05-01aoki_20nagaoka.pdf; Anne Layne-Farrar & Josh Lerner, *To Join or Not to Join: Examining Patent Pool Participation and Rent Sharing Rules* 18 (Nov. 15, 2006), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=945189#PaperDownload.

IV. INCIDENCE, SSO INCENTIVES, AND THE PROTECTION OF FINAL CONSUMERS: STANDARDS HOLD-UP AS A COMPETITION PROBLEM

SSO rules on patent disclosure and licensing have sometimes been judged too vague or too weak to create a serious disclosure or licensing obligation.¹⁵¹ We now discuss internal incentives of the SSO and its members in crafting and enforcing effective rules. As we explain, hold-up is apt to harm final consumers even more than the technology-buying members of an SSO. This can make hold-up of a standard a market-wide competition problem in a way that hold-up of a single buyer tends not to be. It also weakens an SSO's incentive to avert the hold-up problem.

When a single firm over-pays for an input, downstream consumers are harmed only to the extent that the firm increases its output price in response to its cost increase. Even if the firm's marginal or incremental costs, and not just its fixed costs, rise, this pass-through rate will often be small if the firm has little market power. Thus, final consumers may not gain substantially if antitrust protects a single firm in a competitive industry against hold-up.

If the firm has significant market power, its pass-through rate may be substantial, and then downstream buyers are hurt if the firm is held up. However, the firm (direct buyer) bears the full brunt of an input cost increase that applies only to itself, as well as passing some on to its customers.¹⁵² Thus, although consumers can be harmed, they are significantly protected by the direct buyer's self-interest in avoiding hold-up.

¹⁵¹ Rambus Inc. v. Infineon Techs. AG, 318 F.3d 1081, 1098 (Fed. Cir. 2003) [hereinafter *Infineon Appellate Decision*] ("The language of these policy statements actually does not impose any direct duty on members."). See also *id.* at 1102 ("In this case there is a staggering lack of defining details in the EIA/JEDEC patent policy.").

¹⁵² This follows from the envelope theorem applied to the direct buyer, which teaches that the direct effect of a small cost increase cannot be substantially offset by changes in output (or input mix) when profits are already at their maximum. More specifically, the effect on a direct buyer of a small increase in its costs is essentially equal to the direct effect of those higher costs, whether or not the buyer adjusts its downstream price or output in response. This is because the buyer had already set those downstream variables to maximize profits, so the profit impact of readjustments is small even compared to the impact of the small change in its costs. See HAL R. VARIAN, MICROECONOMIC ANALYSIS 45–46, 74–75 (3d ed. 1992). For example, if the direct buyer produces 1000 units and costs go up by \$1 per unit, its profits fall by \$1,000, even after it optimally adjusts its price in response. For the same reason (the envelope theorem, applied now to consumers), if the pass-through rate is 60 percent (say), then consumers also lose 60 cents per unit for a total of \$600, since they continue to purchase (approximately) 1000 units at the new, higher price. This analysis does not rely upon any assumptions about the elasticity of demand. It does apply directly only to small changes in cost, but can be integrated to show that the impacts on both direct buyers and consumers are at least equal to the

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In contrast, when a standard used in a fairly competitive industry is subject to *uniform* hold-up, direct buyers may bear little of the cost, which falls primarily on final consumers. If each direct buyer knows that its rivals are paying as high a royalty as it is, pass-through can largely immunize it against economic loss from high running royalties. Thus, the direct buyers, who might otherwise be the best guardians against gratuitous insertion of patents in standards, or against excessive royalties from such patents, may bear very little of the harm.¹⁵³ For instance, in a Cournot oligopoly with N equal firms, each with constant unit cost c , and facing a market demand elasticity of ϵ , a small increase in all firms' c actually increases their profits if $\epsilon < 1$, and reduces profits only slightly if ϵ is modestly above 1. Similar effects arise in imperfect competition more generally, since cost increases borne uniformly by all oligopolists are generally passed through to a considerable degree. Thus, consumers are not, in general, well protected by the self-interest of direct technology buyers.

Technology users participating in an SSO will be likely to expect uniform hold-up in this sense if each user would be put into a comparably weak position in negotiation with the patent holder, as will tend to be true if most or all of the producers competing downstream are subject to the hold-up. Clearly, this is less likely if (as is common in the microelectronics industry) the patent holder and a substantial set of users have royalty-free cross-licenses that would cover the patents in question. It also depends on whether the patent holder demands running royalties or fixed fees, and on the economics of industry pass-through rates, which vary from case to case.¹⁵⁴ However, uniformity in exposure to hold-up seems more likely in the standards context than in most procurement settings. Indeed, uniform hold-up might also stem from the FRAND policies of SSOs.¹⁵⁵

Even if an SSO is dominated by (direct) buyer interests rather than by patent holders, it has only weak incentives to craft rules to stop hold-up.

corresponding price changes times the lower post-adjustment quantity. Except in the case of industry-wide cost shocks under perfect competition, it is incorrect to assume that the direct and indirect impacts must sum to 100 percent.

¹⁵³ Brief Amicus Curiae of Economics Professors and Scholars at 19, *Rambus Inc.*, FTC Docket No. 9802 (Apr. 15, 2004) [hereinafter *Rambus Inc.*, Economics Amicus], available at <http://www.ftc.gov/os/adjpro/d9802/040415scholarsamicusbrief.pdf>.

¹⁵⁴ For example, the FTC's economic expert in *Rambus* concluded that there would be no pass-through in the short run because DRAM producers would produce at capacity with or without Rambus's royalty demands, but that there would be an effect in the longer run, during which industry capacity could change. *Rambus Inc.*, Opinion of the Commission, *supra* note 10, at 114 n.622.

¹⁵⁵ *Rambus Inc.*, Economics Amicus, *supra* note 153, at 13.

Furthermore, SSOs often represent patent holders as well as technology users, and the rules can be expected to reflect the interests of both.¹⁵⁶ Put another way, if each member thinks it will some of the time be the patent holder that could profitably hold up others, then the SSO's rules cannot be expected fully to protect competition and consumers. In particular, it could actually be counter-productive if non-discrimination policies are more effectively enforced than are fair and reasonable policies.¹⁵⁷

One important caveat is that, if liability is linked to membership in the SSO, strengthening the SSO's anti-hold-up policies might discourage patent holders from joining, at least ones that are confident that their technology will be incorporated into the standard even in their absence.¹⁵⁸ Likewise, some patent holders might not participate if enforcement policies are unclear. On the other hand, stronger anti-hold-up policies may encourage participation because reducing the danger of hold-up can speed the standards process enough that even patent holders gain.¹⁵⁹ Moreover, participation by patent holders, while important, is only part of the goal.

¹⁵⁶ Cf. Chiao et al., *supra* note 29, at 1. However, Teece and Sherry argue that SSOs tend to over-represent technology users' interests. Teece & Sherry, *supra* note 24, at 1928, 1931.

¹⁵⁷ The MPEG-2 and DVD-ROM/DVD-Video patent pool business review letters also address this theory of harm. Klein June 26, 1997 Beeney Business Review Letter, *supra* note 150, at 11–15. "Since the contemplated royalty rates are likely to constitute a tiny fraction of MPEG-2 products' prices, at least in the near term, it appears highly unlikely that the royalty rate could be used during that period as a device to coordinate the prices of downstream products." *Id.* at 11. "First, the agreed royalty is sufficiently small relative to the total costs of manufacture that it is unlikely to enable collusion among sellers of DVD players or discs." Business Review Letter from Joel I. Klein, Ass't Attorney General, U.S. Dep't of Justice, to Gerrard R. Beeney, Sullivan & Cromwell 18 (Dec. 16, 1998), available at <http://www.usdoj.gov/atr/public/busreview/2121.pdf>; see also Klein June 10, 1999 Ramos Business Review Letter, *supra* note 150, at 14 (using substantially similar language).

An even more worrying possibility, but not (as far as we know) one that has allegedly happened, is that the SSO could gratuitously incorporate use of many of its members' patents so that all could charge royalties at downstream consumers' expense. When the downstream market price is below the monopoly level, producers collectively have an incentive to agree to a running royalty if it is redistributed among them. Laffont, Rey, and Tirole explored an analogous issue (mutual above-cost interconnection charges) in the telecom context, although they argued there that the collusive outcome is not stable. See generally Jean-Jacques Laffont et al., *Network Competition: Overview and Nondiscriminatory Pricing* (pt. I), 29 RAND J. ECON. 1 (1998).

¹⁵⁸ Rambus was advised by counsel to withdraw from JEDEC in late 1995, and did so. *Rambus Inc.,* Opinion of the Commission, *supra* note 16, at 44. If Rambus had never joined JEDEC, its ex post royalties would not have been constrained by RAND requirements. On the other hand, its patent applications might not have been revised to cover JEDEC technologies.

¹⁵⁹ See Farrell & Simcoe, *supra* note 70, at 4, 21.

A more philosophical argument against intervention is that hold-up is a well-known problem and that if SSO members knew they might be held up, and chose to participate anyway, public policy need not step in to protect them. However, public antitrust enforcement is largely concerned about effects on downstream consumers, who were not a party to that bargain. And, as we stressed above, SSO members may lose little from hold-up, and may benefit as often as they suffer, so their private interests do not in general fully reflect consumers' interests. A more consequentialist response is that surprise hold-up may be largely a transfer, but anticipation of hold-up encourages a range of inefficient forms of self-protection, such as postponing or minimizing investment, or ensuring that standards use only antique technology.

V. ANTITRUST SCREENING USING MARKET POWER TESTS

Consistent with our analysis above, we focus on the *increment* to market power enabled by standards hold-up. Recalling that MP_p denotes ex post market power with (or after) the challenged conduct, and MP_A denotes ex ante market power without (or before) that conduct, one necessary condition for liability is that the difference, $\Delta = MP_p - MP_A$, be substantial. We now discuss how the traditional indirect steps of defining a relevant market, measuring the defendant's market share, and assessing its *level* of market power could help screen cases for more detailed analysis, although, when competitive effects can be shown directly, we need not rely on those indirect methods. We then propose a different screen, more closely tailored to the generic theory of these cases and potentially more useful for efficiently screening out some cases with little merit.

A. MARKET DEFINITION

The reduction in rivalry due to standards hold-up takes place in a technology market: the SSO is choosing technology to be used in downstream products or services, and there is competition to be the chosen technology.¹⁶⁰ This directly suggests that the relevant market is a technology market or markets, and we pursue that logical approach.

More concrete competitive effects may occur in a downstream product market or markets, and we use that perspective below in discussing competition from products that do not conform to the standard. But the product market is not the locus of the concern, and in some cases (such as *Rambus*) the patentee does not even produce downstream.

¹⁶⁰ Of course, there may be multiple relevant technology markets, and there need be no simple correspondence between technology markets and patents or patent claims.

Highly competitive conditions downstream do not protect against hold-up (and may even make it more likely), and monopoly downstream does not imply hold-up.

B. SCREENING FOR EX ANTE OR EX POST MARKET POWER

On its own, a market power screen based on ex ante market power, MP_A , makes no logical or economic sense. As many have emphasized, a patent does not confer market power if the patented technology faces very close substitutes.¹⁶¹ Furthermore, in assessing ex ante market power, one must beware of falling into the *Cellophane* fallacy.¹⁶² And cases where there is little or no ex ante market power, but a great deal of ex post market power, can be the most troublesome: the patent can command high royalties based on hold-up even though the technology is not inherently superior. Therefore, defining a technology market ex ante, and measuring market power in this market, is not a sensible way to develop a market power screen for patent hold-up cases, although (as we discuss below) an estimate of ex ante market power, MP_A , can be helpful in remedy analysis.¹⁶³

In contrast, a screen based on ex post market power may have some use. The antitrust concern is that, by engaging in hold-up, a patent holder could substantially augment its market power. Clearly, if the patent confers no significant ex post market power, then the patent holder could not have significantly augmented its market power by any challenged conduct, since $\Delta \leq MP_P$. Moreover, it may be relatively straight-

¹⁶¹ See, e.g., ANTITRUST ENFORCEMENT AND IP, *supra* note 121, at 22; U.S. Dep't of Justice & Fed. Trade Comm'n, Antitrust Guidelines for the Licensing of Intellectual Property § 2.2 (1995), available at <http://www.usdoj.gov/atr/public/guidelines/0553.htm>.

¹⁶² More specifically, licensees will typically have substitutes to the patented technology at the royalty rate charged by the patent holder; if not, the patent holder would find it more profitable to set a higher royalty rate. So, observing such substitution is not informative regarding the magnitude of ex ante market power. Mistakenly relying on evidence of buyer substitution at status quo prices to infer a lack of market power has become known as the "*Cellophane* fallacy" since the Supreme Court notoriously committed this error in *United States v. E.I. du Pont de Nemours & Co.*, 331 U.S. 377 (1958). For further discussion on this point, see Louis Kaplow & Carl Shapiro, *Antitrust*, in HANDBOOK OF LAW AND ECONOMICS 1190 (A. Mitchell Polinsky & Steven Shavell eds., 2007).

¹⁶³ Klein and others have stressed that when behavior ex post is adequately governed by ex ante contracts, the correct competitive analysis is ex ante. We agree, and, hence, our focus on situations in which incremental ex post market power is not effectively controlled by ex ante contracts. Hold-up arises precisely when ex ante contracts fail to reflect ex ante competition or fail to govern ex post behavior: indeed, this is the approach to FRAND enforcement that we recommend above. Cf. Benjamin Klein, *Market Power in Antitrust: Economic Analysis after Kodak*, 3 SUP. CT. ECON. REV. 43, 85 (1993); Benjamin Klein, *Market Power in Franchise Cases in the Wake of Kodak: Applying Post-Contract Hold-Up Analysis to Vertical Relationships*, 67 ANTITRUST L.J. 283, 296–97 (1999).

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forward to assess market power *ex post*. Thus, a screen based on *ex post* market power is sensible and potentially useful.

Unfortunately, while a screen based on *ex post* market power is unobjectionable, it is weak: essential patents that generate litigation typically confer market power *ex post*, so the inquiry will seldom stop with this screen. If the standard is important in downstream product markets, one would naturally define an *ex post* technology market to include all technologies that can implement reasonably efficiently the feature at issue while complying with the standard. So the owner of a patent that is essential to the standard would have a monopoly (and a share of 100 percent) in this market.¹⁶⁴ This of course does not finish the analysis, but it does mean that inquiries can seldom stop at this point based on finding that the patent holder lacks market power.

Conceptually, a patent essential to this standard could lack market power because products covered by the standard compete against other products that do not comply with the standard (and do not infringe the patent).¹⁶⁵ But the conditions for this to eliminate meaningful *ex post* market power are typically stringent. Even if demand for the standard-compliant final product is quite elastic, perhaps due to competition from products that use older technology or competing standards, the derived demand facing the owner of an essential input (here, a patent) can be quite inelastic, reflecting significant market power. Suppose that the price for the standardized product is P , the elasticity of demand for the standardized product is E , the rate at which royalties are passed through to the price of the standardized product is k (note that $k = 1$ if the standardized product is sold in a perfectly competitive downstream market with constant marginal cost), and the per-unit royalty for the essential patent is r . Then the elasticity of demand facing the patent holder is equal to $Ek(r/P)$.¹⁶⁶ For example, if the elasticity of demand for the product is $E = 4$, the royalty rate is 5 percent (so $r/P = 0.05$) and the

¹⁶⁴ The analysis is more complex if the patent only covers one method of implementing the feature at issue, with other methods specified as options under the standard. We do not analyze such non-essential patents here. We also note that, when there are multiple owners of patents essential to the standard, it follows, even though it is verbally uncomfortable, that there are multiple monopolists.

¹⁶⁵ This suggests that it could be useful to examine downstream product markets as well as the technology market. Since the competitive concern is really in the technology market and the patent holder may not be integrated into product markets, the downstream product market cannot in practice serve as the relevant market.

¹⁶⁶ Write demand for the product as $X = D(P)$. The elasticity of demand for the product is defined as $E = -(dX/dP)(P/X)$. The elasticity of demand for the patented technology is defined as $e = -(dX/dr)(r/X)$, so $e = -(dX/dP)(P/X)(r/P)(dP/dr) = E(r/P)(dP/dr)$. With a pass-through rate of $dP/dr = k$, this implies that $e = Ek(r/P)$.

pass-through rate is $k = 1$, then the elasticity of demand for the patented technology is $(4)(1)(0.05) = 0.2$.¹⁶⁷

C. SCREENING FOR AN INCREMENT TO MARKET POWER

A more logical and helpful screen asks whether there plausibly was a substantial *increase* in market power. In particular, one can investigate whether there are specific investments in standardized technologies, or other economic factors, such as network effects, that render the (ex ante) available alternatives substantially less attractive ex post.¹⁶⁸ That is, one can examine $V_p - V_A$, and perhaps $\Delta \equiv MP_p - MP_A$.

This focus on Δ has a number of attractive properties. First, Δ measures the competitive effects that are the underlying concern, so this screen directly addresses the problem at hand. Second, lock-in may be relatively straightforward to identify and quantify (as already discussed, Δ can sometimes be quantitatively estimated), so this screen is practical. Depending on the case, it may even be prudent to postpone analysis of bargaining or price setting, and base the screen on $V_p - V_A$ (dismissing the case if that difference is small) rather than seeking to estimate Δ itself. For that version of the screen, evidence of commitment through sunk investments, challenging coordination issues, and the like, would suffice.

Because plaintiffs probably are well placed to document their lock-in, it seems sensible at this screening stage to require them to show that they are less able to substitute away from the patent(s) than they would have been earlier. But this screening stage is not the time to ask whether the SSO, or the industry, *would have* behaved differently had the patent been disclosed. As we see next, such issues of causation may be particularly nuanced and, hence, unsuited to a screen, however important they are to a full case.

¹⁶⁷ This calculation raises the question of what running royalty rate maximizes the profit of the owner of an essential patent. With zero marginal cost, profit maximization involves setting the running royalty rate at the level that maximizes total royalty income (we are assuming here that the patent holder only charges running royalties and does not also charge a fixed fee), which occurs at the royalty rate where the elasticity of demand facing the patent holder equals unity. If this rate is well above the rate actually sought by the patent holder, it is reasonable to infer that other constraints limit the royalty rate, such as the threat that the patent will be challenged and found invalid or the threat that the rate sought will be judged to violate the patent holder's FRAND commitment.

¹⁶⁸ Put differently, one could examine whether ex ante switching costs differ from ex post switching costs.

IV. CAUSATION

Did the patent holder's challenged conduct *cause* (or substantially contribute to) the increase in market power? Causation means that the conduct caused lock-in via commitment to the standard. This causation inquiry raises subtle issues, both substantively and in terms of sensible presumptions and appropriate burdens of proof.¹⁶⁹

Causation may be assessed in two steps: first, we consider whether the conduct caused the SSO to adopt the standard that it adopted, with only those (ex post insufficient) protections against hold-up that were implemented; second, we consider whether those SSO choices caused market participants to sink investments and otherwise commit to use of the technology.¹⁷⁰

A. DID THE CHALLENGED CONDUCT AFFECT SSO STANDARDIZATION?

In deception cases, the SSO might have adopted the same standard, even if the patent holder had disclosed its patents and its intention to seek royalties.¹⁷¹ Unocal and Rambus both raised variants of this argument, claiming essentially that the industry perceived their technologies to be so good (or their patents to be so weak) that they would have adopted them even if alerted early (a claim that is presumably more plausible, the more protective RAND policies are thought to be in practice).¹⁷² The administrative law judge in *Rambus* agreed, holding that "the evidence demonstrates that even if Respondent had made the addi-

¹⁶⁹ First, however, note two simple causation fallacies. While the patent holder would have no ex post power without its patent, that does not imply that its power is only due to the patent (and, thus, legitimate); it is also due to the lock-in forces that increased its power. As noted above, the *Townshend* court seemed to make this error. Cf. *Townshend v. Rockwell Int'l Corp.*, 55 U.S.P.Q.2d (BNA) 1011, 1022 (N.D. Cal. Mar. 28, 2000). Similarly, even if the hold-up in some sense arose due to the SSO's decision, that does not imply that it was not *also* caused by the patent holder's conduct. The district court in *Broadcom* appears to make this latter error, see *Broadcom Corp. v. Qualcomm Inc.*, 2006 U.S. Dist. LEXIS 62090, at *25 (D.N.J. Sept. 19, 2006), *aff'd in part, rev'd in part*, 501 F.3d 297 (3d Cir. 2007), which the Third Circuit corrected. See *Broadcom Corp. v. Qualcomm Inc.*, 501 F.3d 297, 313–14 (3d Cir. 2007).

¹⁷⁰ This division need not be so absolute, however. For instance, even given the SSO standard, participants might well be more cautious in sinking investments if they know of an essential patent.

¹⁷¹ The causation inquiry is different in cases where there is a dispute over what constitute fair and reasonable royalties. If the SSO would not have accepted ex ante the terms offered ex post by the patent holder, those terms cannot be fair and reasonable. Fair and reasonable royalties are those that would have been negotiated in the presence of ex ante technology competition. Typically, these are less than the maximum royalties that the SSO or its members would pay ex ante, since suppliers and buyers usually split their gains from trade.

¹⁷² *Unocal* Respondent's Post-Trial Brief, *supra* note 62, § IV.B.2.c; Initial Post-Trial Brief of Respondent Rambus Inc., § V, Rambus Inc., FTC Docket No. 9302 (Sept. 9, 2003)

tional disclosures alleged to have been required, rational manufacturers and a rational JEDEC would have selected Respondent's technologies because the proposed alternatives were inferior⁷³ Likewise, a notable antitrust treatise states:

[A]n antitrust plaintiff must establish that the standard-setting organization would not have adopted the standard in question but for the misrepresentation or omission. This causation requirement is needed because the failure to disclose the existence of a patent to a standard-setting organization will not affect the competitive marketplace if the standard-setting organization would have approved the standard even if it had known about the patent.⁷⁴

And *Townshend* suggests that a successful plaintiff must at least show that a different standard *could* have resulted.⁷⁵

But this reasoning is fundamentally flawed: even if truthful disclosure would not have led to the selection of a different standard, presumably because $V_A > 0$, it might well have led to more favorable terms for technology users, such as a lower royalty rate. Indeed, in a case that passes the screen based on the increment Δ to market power, a higher royalty rate will predictably result from *ex post* negotiation (unless effectively constrained by FRAND) than *ex ante* negotiation. Competition with network effects and/or switching costs pressures suppliers to make *ex ante*

[hereinafter *Rambus Inc.*, Respondent Post-Trial Brief], available at <http://www.ftc.gov/os/adjpro/d9802/080909raminitialposttrialbrief.pdf>.

⁷³ *Rambus Inc.*, Initial Decision, *supra* note 126, at 333; see also *Rambus Inc.*, Opinion of the Commission, *supra* note 10, § IV.C.3.

⁷⁴ HERBERT HOVENKAMP ET AL., IP AND ANTITRUST: AN ANALYSIS OF ANTITRUST PRINCIPLES APPLIED TO INTELLECTUAL PROPERTY LAW § 25.5, at 35–45 (2007). This statement implicitly assumes that the SSO and its members would not have sought any concessions or commitments by the patent holder. It also assigns the burden of proof rather quickly, in view of the inherent difficulty of modeling counterfactual market behavior in the presence of network effects.

⁷⁵ “Conexant has not asserted that the ITU could have adopted a V.90 standard which did not encompass Townshend’s technology, whereas in *Dell* . . . there was a possibility that they could have adopted a standard which did not incorporate Dell’s patent.” *Townshend v. Rockwell Int’l Corp.*, 56 U.S.P.Q.2d (BNA) 1011, 1021 (N.D. Cal. Mar. 28, 2000). *Dell* states in relevant part:

We believe that in the limited circumstances presented by this case, enforcement action is appropriate. In this case—where there is evidence that the association would have implemented a different non-proprietary design had it been informed of the patent conflict during the certification process, and where Dell failed to act in good faith to identify and disclose patent conflicts—enforcement action is appropriate to prevent harm to competition and consumers.

Dell Complaint, Decision and Order, *supra* note 6, at *15.

Kattan also cites *Townshend* for the proposition that “causation requires the showing of a causal link between the standard-setting conduct and the adoption of a standard that infringes the wrongdoer’s patent.” Kattan, *supra* note 24, at 27 (citing *Townshend*, 55 U.S.P.Q.2d (BNA) at 1022).

concessions, precisely *because* they stand to gain market power ex post. And ex ante technology competition will encourage the patent holder, as well as users, to seek out ways to constrain the royalties charged ex post. The district court in *Broadcom* also failed to recognize this basic point;¹⁷⁶ in reversing, the Third Circuit emphasized the “critical competitive period that precedes adoption of a standard.”¹⁷⁷

B. DID SSO STANDARDIZATION AFFECT MARKET ADOPTION?

Another inquiry into causation in deception cases asks whether the SSO had a substantial role in causing widespread market adoption of the patented technology.¹⁷⁸ If the patented technology was dramatically superior ex ante, perhaps industry participants would have adopted it even if the SSO had picked a different standard or no standard. It could, thus, be that SSO selection of the standard did not affect industry participants’ actual adoption of the patented technology or their subsequent ability to switch to alternatives. In this case, the patent holder’s conduct at the SSO did not contribute, via influencing the SSO’s choice, to actual on-the-ground adoption of the patented technology.

But, again, this does not imply that there was no competitive effect. In the broadest terms, showing that V_A (or even MP_A) is substantial cannot show that A is small. More concretely, standards battles often involve intense competition, to the benefit of users, before a winner emerges.¹⁷⁹

C. PRESUMPTIONS AND BURDENS OF PROOF REGARDING CAUSATION

It is inherently difficult to determine how an SSO *would have* behaved in a but-for world, and de facto standards battles are notoriously unstable and “tippy.” Therefore, a burden of proof regarding what would have happened in the absence of deceptive conduct by the patent holder may be hard for either party to meet. What does economics tell us about how it should be assigned?

¹⁷⁶ *Broadcom Corp. v. Qualcomm Inc.*, 2006 U.S. Dist. LEXIS 62090, at *27 (D.N.J. Sept. 19, 2006), *aff’d in part, rev’d in part*, 501 F.3d 297 (3d Cir. 2007).

¹⁷⁷ *Broadcom Corp. v. Qualcomm Inc.*, 501 F.3d 297, 313 (3d Cir. 2007).

¹⁷⁸ For example, Rambus’s economic expert made the argument—accepted by the ALJ—that Rambus’s market power was unaffected by the fact that JEDEC standardized on the Rambus technology. He argued that the Rambus technology was superior and so JEDEC standardization on it did not alter the possibility of substitution to other technologies. *Rambus Inc.*, Initial Decision, *supra* note 136, at 154.

¹⁷⁹ In some circumstances an ex ante clearly *predictable* winner may not need to engage in penetration pricing and compete fiercely to attract pivotal users. See, e.g., Michael L. Katz & Carl Shapiro, *Product Introduction with Network Externalities*, 40 J. INDUS. ECON. 55, 73 (1992); Farrell & Katz, *Compatibility and Innovation*, *supra* note 44, at 644 n.28. But, normally, even winners must compete.

Decision theory suggests three principles. First, other things equal, the presumption should be the answer that is more likely to be true *a priori* (presumptions should reflect priors); and that principle applies more strongly the less likely it is that mistaken presumptions will be overturned (because of the difficulty or cost of proving what is true). Second, other things equal, the burden should be assigned to the party that, if it is in the right, is more likely to be able to prove it. Finally, one should consider the market consequences of systematic tendencies towards false positives or false negatives. These are deep issues and we do not resolve them here, but instead offer three potentially helpful observations.

1. Revealed-Preference Presumption

A firm's actions can illuminate what it thought the effects of its choices would be, and this can offer substantial evidence on causation.¹⁸⁰ For instance, the patent holder may have delayed asserting its patents (sacrificing short-run royalties, and possibly jeopardizing patent enforceability) until switching costs grew.¹⁸¹ Such conduct may be hard to explain if the patent holder were confident that full disclosure would have no effect.

Thus, Rambus reportedly delayed disclosing its SDRAM patents because "our leverage is better to wait."¹⁸² Rambus argued that, even if it had disclosed its applications, JEDEC participants might have ignored the disclosure, expecting that Rambus would never be granted a patent or that any patent could be ruled invalid due to prior art.¹⁸³ But then why not disclose? The FTC found that "Rambus understood that knowledge of its evolving patent position would be material to JEDEC's choices, and avoided disclosure for that very reason."¹⁸⁴ Likewise, Unocal argued that CARB had not tried to avoid an issued (but not fully adjudicated) Unocal patent because it viewed the patent's enforceability as still too uncertain; thus, Unocal claimed, "CARB would not have en-

¹⁸⁰ *Trinko*, for example, links evidence that the monopolist (or attempted monopolist) sacrificed short-run profits for potential long-run gains to a conclusion that competition was harmed. *Verizon Commc'ns, Inc. v. Law Offices of Curtis V. Trinko, LLP*, 540 U.S. 398, 409 (2004).

¹⁸¹ Wang delayed enforcing its patents and was found to have given an implied license. *See Wang Labs., Inc., v. Mitsubishi Elecs. Am. Inc.*, 103 F.3d 1571, 1573 (Fed. Cir. 1997).

¹⁸² *See Rambus Inc., Opinion of the Commission*, *supra* note 10, at 47, 65, 71.

¹⁸³ Brief of Appellee and Cross-Appellant Rambus Inc. 68, Rambus Inc., FTC Docket No. 9302 (Jan. 2, 2004), available at http://www.ftc.gov/os/adjpro/d9302/040602rambs_briefappellee.pdf. An additional wrinkle is that JEDEC participants could have thought Rambus was trying to derail the SDRAM standards process in the hope of pushing the industry to RDRAM, on which Rambus was known to have patents.

¹⁸⁴ *Rambus Inc., Opinion of the Commission*, *supra* note 10, at 68.

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acted different regulations based on knowledge that Unocal had merely applied for a patent.”¹⁸⁵ Again, if that were clear at the time, one could ask why Unocal engaged (if it did) in misleading and deceptive behavior at CARB.

But this inference may be weakened if the patent holder’s actions could be explained in other ways, even if those other ways are inefficient or not laudable. For example, Rambus argued that it worried disclosure would hinder its patent applications or endanger its patent rights.¹⁸⁶ If this means that Rambus believed its applications were weak and wanted to keep others from alerting the PTO to those weaknesses, that hardly seems efficient or procompetitive, but it might nevertheless weaken an inference that Rambus believed JEDEC (or the market) would have behaved differently had it known of the Rambus applications.

2. Proving Counterfactual SSO Conduct

The SSO’s record of responding to patent disclosures is relevant to assessing how it would have responded had the patent holder disclosed patents. The FTC found that, given JEDEC’s concerns about costs and its past challenges to companies that sought royalties on undisclosed patents, “it makes little sense that JEDEC members . . . would, if they had known about Rambus’s patents and patent applications, simply have ignored them . . . ”¹⁸⁷ One issue is whether other JEDEC members might have responded differently to learning of a Rambus patent than to learning of a patent held by a manufacturer, which might have royalty-free cross-licenses with some others and which might be more concerned about retaliation.

3. Proving Counterfactual Market Dynamics

The outcome of de facto standards battles is generally unpredictable. Positive-feedback dynamics make market behavior unstable early, then later produces lock-in. As a result, it will generally be hard to predict what would have happened if the SSO had chosen no standard, or to be confident whether the market would have adopted the technology subject to patents even if the SSO had chosen another technology for the standard. Thus, there is much to be said for not requiring parties to establish what the but-for alternative would have been, which would make antitrust liability turn on a court’s inevitably imperfect finding about the “but-for” technology choice. Similarly, in exclusion cases,

¹⁸⁵ *Unocal* Respondent’s Post-Trial Brief, *supra* note 62, at 102; *id.* at 41.

¹⁸⁶ *Rambus Inc.*, Respondent Post-Trial Brief, *supra* note 172, at 109–14.

¹⁸⁷ *Rambus Inc.*, Opinion of the Commission, *supra* note 10, at 65.

some courts have based antitrust liability on reduced rivalry, without a need to trace through what customers would have done absent the conduct.¹⁸⁸

VII. NATURE OF DEFENDANT'S CONDUCT

Assume now that (with appropriate presumptions and burdens of proof) the court is satisfied that the defendant's conduct increased its market power via hold-up. An antitrust court will then ask whether that conduct was "anticompetitive." Given that the conduct led to an increase in market power, to the detriment of consumers, one might ask exactly what this additional requirement means. Here we assume that it means that if the conduct is condemned in this case, others will be deterred from "similar" conduct elsewhere irrespective of its effects specifically there, and that this deterrence ought to help, or not hurt, competition.¹⁸⁹ This is sometimes expressed by requiring that the conduct not be "competition on the merits" (that is, a "category" of conduct that, even if harmful here, should not generally be deterred), or more strongly that it involve "bad acts" (that should generally be deterred). Among acts that may substantially increase a patent's market power through hold-up, some look clearly "bad," but there is an important gray area of acts that are not "competition on the merits" but also not clearly "bad acts." As usual in antitrust, sorting out the effects of various forms of conduct is complex; we sketch here some initial ideas.

A. MISLEADING AND DECEPTIVE CONDUCT

Active deception might constitute fraud or breach of contract.¹⁹⁰ Rambus, for example, was found liable for fraud in private litigation, although the finding was overturned on appeal.¹⁹¹ Nokia has alleged

¹⁸⁸ See *United States v. Microsoft Corp.*, 253 F.3d 34, 79 (D.C. Cir. 2001). While the *Microsoft* court found liability with substantial uncertainty regarding the but-for world, it described this as an "edentulous" standard and said the uncertainty was relevant for remedy. *Id.*

¹⁸⁹ If others are deterred only when their acts in fact would have harmed competition, such deterrence will clearly promote competition. However, if sanctioning the conduct at issue will deter some anticompetitive conduct as well as some procompetitive conduct, a more difficult balancing is needed. Of course, this is common in the law, and highlights the importance of defining carefully just what aspects of the conduct triggered liability so that "similar" conduct will indeed typically be anticompetitive.

¹⁹⁰ Then-Assistant Attorney General Pate noted that: "If a participant agrees to disclose but then fails to do so, it can be liable for breach of contract or fraud. Such liability would hinge on a pattern of breaches, frauds, or other unlawful conduct. If antitrust liability is also contemplated, it would require, in addition, proof of market effects." Pate, *supra* note 75, at 9.

¹⁹¹ *Rambus Inc. v. Infineon Techs. AG*, 318 F.3d 1081, 1084 (Fed. Cir. 2003).

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that Qualcomm's refusal to license patents that read on an ETSI mobile wireless standard on FRAND terms is a breach of contract with ETSI and ETSI members, including Nokia.¹⁹²

But antitrust need not be reduced to a piling-on statute that attacks only behavior that is already otherwise illegal. Misleading and deceptive conduct is very difficult to defend as competition on the merits, and may surely be a "bad act" if it leads to monopolization, even if it is not breach of contract or fraud.¹⁹³ Unocal, for example, was accused of promising (*ex ante*) to make its empirical studies of the emissions properties of reformulated gasoline freely available yet subsequently seeking royalties.¹⁹⁴ Similarly, Dell's false representation that it did not have patents covering VESA's VL-bus standard may not have been otherwise illegal, but in the context of a standards development process with a disclosure obligation, the FTC issued a complaint.¹⁹⁵

A defendant may argue that deception is harmless if its effect is to cause the patented technology to be adopted and if that technology is superior to the alternatives.¹⁹⁶ But this argument is flawed, for two fundamental reasons noted above. First, deception undermines the process of technology competition as a means of selecting the best technology at a competitive price and, thus, is antithetical to antitrust policy, even if, after the market test is subverted, there are other reasons to hope that the best technology was adopted. Second, deception typically enriches the deceptive party at the expense of others, even if it does not alter the technology that is selected for the standard. A rule under which there would be no antitrust liability if the defendant's patent covered the best technology would effectively allow any owner of superior technology to engage in deceptive behavior to augment its market power through opportunism.

B. VIOLATION OF SSO DISCLOSURE RULES

Next, suppose that the patent holder has not engaged in outright deception but did violate SSO disclosure rules. Courts have looked to SSO

¹⁹² *Nokia Corp. v. Qualcomm Inc.*, C.A. 2330-N (Del. Ch.), Complaint, ¶ 1. Authors Farrell, Hayes, and Shapiro have been retained by Nokia in this litigation.

¹⁹³ The Commission's *Rambus* opinion reviewed antitrust law regarding deceptive conduct. *Rambus Inc.*, Opinion of the Commission, *supra* note 10, at 28–30, 32–35.

¹⁹⁴ *Unocal* Complaint, *supra* note 22, ¶2.

¹⁹⁵ *Dell* Complaint, Decision and Order, *supra* note 6, at *18.

¹⁹⁶ For a description of a version of this argument, discussing *ex post* deadweight loss from pricing as well as the technical merits, see Teece & Sherry, *supra* note 24, Appendix.

rules for guidance on what conduct might be sanctioned.¹⁹⁷ This can be sensible: SSO members may be more likely to be actively deceived if other members assumed the patent holder would obey specific rules, and the SSO may be able to tailor its policies to the industry.¹⁹⁸ However, as discussed above, SSOs have only imperfect tools, and their incentives are imperfectly aligned with competition, efficiency, or consumer interests. Thus, SSO rules should not be the last word on whether conduct violates the antitrust laws—in particular, compliance with SSO rules should not prevent the imposition of liability.

Various *Rambus* courts have treated this issue differently. After a contrary decision by its administrative law judge (ALJ), the FTC held that JEDEC's disclosure policies fostered an expectation that patents and applications applicable to JEDEC's work would be disclosed.¹⁹⁹ Rambus misled JEDEC by, among other things, selectively disclosing patents that did not cover standards—thus suggesting that it was following the disclosure rules—while not disclosing its efforts to patent technologies under consideration for a standard.²⁰⁰ The *Infineon* court and the ALJ concluded that Rambus did *not* clearly violate those rules, perhaps because the court felt that those rules evince a “staggering lack of defining details.”²⁰¹ In reviewing a finding of fraud, the *Infineon* court found this decisive and reversed. But while the FTC's *Rambus Opinion* does not find that Rambus literally violated JEDEC's disclosure rules, the Commission took the view that literal violation of the SSO's rules is not necessary for an antitrust violation.²⁰²

C. FAILURE TO OFFER LICENSES ON FRAND TERMS

Several cases have alleged that a patent holder promised (ex ante) to offer FRAND terms, but subsequently (ex post) did not. As noted, Broadcom has alleged that Qualcomm refuses to offer FRAND terms, as

¹⁹⁷ See generally *Rambus Inc. v. Infineon Techs. AG*, 318 F.3d 1081, 1096–102 (Fed. Cir. 2003).

¹⁹⁸ See Teece & Sherry, *supra* note 24, at 1943–45.

¹⁹⁹ *Rambus Inc.*, Opinion of the Commission, *supra* note 16, at 66.

²⁰⁰ *Id.* at 66–68.

²⁰¹ *Rambus Inc. v. Infineon*, 318 F.3d at 1102. See also *Rambus Inc.*, Initial Decision, *supra* note 136, at 273. Likewise, the *Townshend* court dismissed an antitrust claim in part because the patent holder had complied with the SSO's disclosure rules. *Townshend v. Rockwell Int'l Corp.*, 55 U.S.P.Q.2d (BNA) 1011, 1023 (N.D. Cal. Mar. 28, 2006).

²⁰² In a concurrence, Commissioner Leibowitz stressed that, even if Rambus had not been found guilty under Section 2 of the Sherman Act, its conduct would have violated Section 5 (unfair competition) of the FTC Act. Concurring Opinion of FTC Commissioner Jon Leibowitz 1–2, *Rambus Inc.*, FTC Docket No. 9302 (Aug. 2, 2006), available at <http://www.ftc.gov/os/adjpro/d9302/060802rambusconcurringopinionofcommissionerleibowitz.pdf>.

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promised, for patents included in UMTS.²⁰³ Rockwell likewise claimed that Motorola refused *ex post* to offer FRAND terms, after agreeing to do so *ex ante*.²⁰⁴

Conceptually, demanding non-FRAND royalties *ex post* is either deceptive (the patent holder's representation that it would offer FRAND licenses was untruthful) or the breaking of a commitment (the patent holder subsequently decided not to honor its FRAND commitment). But judging whether a specific royalty offer is or is not FRAND will often be difficult for a court, even if the court adopts the consensus view among economists that FRAND should be based on *ex ante* technology competition.

While patent hold-up cases involve an illegitimate increase in market power, in these FRAND cases a patent holder's increase in market power is to some degree negotiated and approved in advance by technology users, and the cases concern the interpretation and enforcement of the conditions imposed on such approval. Although these cases share elements with garden variety breach of contract disputes, they typically raise antitrust issues as well, since a failure by the patent holder to license on FRAND terms imposes costs on final consumers, not just on direct licensees.

D. OTHER TYPES OF CONDUCT

Other types of conduct may also be challenged as antitrust violations.²⁰⁵ Only time will tell what types of conduct elicit complaints and how the courts evaluate these complaints.

VIII. REMEDIES

Antitrust remedies generally seek to restore competition and compensate injured parties for antitrust harm they have suffered. The trebling of actual damages, and criminal sanctions in price-fixing cases, serve a deterrence function.

²⁰³ *Broadcom* Complaint, *supra* note 18, at 4.

²⁰⁴ *Motorola, Inc. v. Rockwell Int'l*, No. 95-575-SLR (D. Del. 1995). Authors Shapiro and Sullivan were retained by Rockwell in this case.

²⁰⁵ For example, a patent owner may make FRAND or similar commitments, then transfer relevant patents to another company that then claims not to be bound by those commitments. See Robert A. Skitol, Counsel for VITA Standards Org., Presentation to FTC/DOJ Hearings on Exclusionary Conduct: How the Agencies Should Assist SDOs in Protecting their Processes from Exclusionary Patent Holdup Conduct 3 (Jan. 30, 2007), available at http://www.usdoj.gov/atr/public/hearings/single_firm/docs/221415.pdf.

In standards hold-up cases, truly restoring technology *competition* will typically be impossible: costs have been sunk and it may no longer be practical or efficient for users to turn to technological alternatives, or to use these alternatives effectively in bargaining over royalty rates. Restoring a competitive outcome may be possible, however, by limiting royalties and other license terms to those that would have resulted had the patents been disclosed and licensing terms been bindingly negotiated *ex ante*. The FTC followed this approach in *Rambus*, relying on licensing terms negotiated for related technologies to estimate the *ex ante* royalty.²⁰⁶ Similarly, if the patent holder made representations *ex ante* regarding licensing terms—perhaps actually representing that the (later found to be patented) technology was in the public domain—then one can argue that the competitive outcome was for the SSO to rely on those representations and a good remedy is to enforce them. That is, the patent holder is held to the representations it made when facing (more effective) technology competition, as author Shapiro recommended in *Unocal*.²⁰⁷ Restoring the *ex ante* competitive outcome will not generally lead to royalty-free licenses.²⁰⁸ But implementation of this concept places heavy demands on assessments of causation: one cannot generally know with certainty what those terms would have been.

The two categories of deceptive conduct that we have focused on here are failures to disclose patents and violations of FRAND promises after patents are included in a standard. At least in cases involving conduct that is clearly misleading or deceptive, we see more danger in too lax than in too stringent a remedy, because patent holders have an excellent recourse if courts generally impose too-stringent remedies: they can refrain from misleading SSO members. In this regard, it is distressing that, to support its reasoning on remedy, the FTC resolved in Rambus's favor the uncertainty about whether Rambus's conduct caused JEDEC to adopt the DDR-2 standard (via its adoption of the SDRAM and DDR standards, where causation was established).²⁰⁹

Proper enforcement of FRAND terms may restore the competitive outcome but is unlikely to deter attempts at hold-up. Worse, a remedy that allowed the patent holder to charge its *ex ante* inherent advantage V_A would typically be inadequate even to restore the competitive outcome (since this is an upper bound on what that the patent holder

²⁰⁶ *Rambus Inc.*, Remedy Opinion, *supra* note 16, at 17.

²⁰⁷ See Shapiro *Unocal* Testimony, *supra* note 63, at 7100.

²⁰⁸ See *Rambus Inc.*, Remedy Opinion, *supra* note 16, at 10.

²⁰⁹ *Id.* at 30.

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might have achieved *ex ante*), and encourages patent holders to engage in deception even if they were sure to be caught.

IX. CONCLUSION

The economics of hold-up and opportunism provide a solid foundation for concerns about consumer welfare and economic efficiency when patent holders engage in deception or strategically postpone disclosure and assertion of their patents. Economics yields several further lessons for such cases. First, economics implies a focus on the increment to market power, not on its pre-existing or later level. Second, economics offers a guiding principle of seeking to restore what would have emerged from open, well-informed *ex ante* technology competition. Third, while SSO rules as written may broadly follow that principle and seek to preserve the benefits of such competition without actual *ex ante* negotiation, economics suggests that the incentives even of "technology buyer" members of SSOs to prevent hold-up may be inefficiently weak, and efficiency, including efficient rewards for innovation, may be well served by antitrust enforcement that goes beyond an enforcement mechanism for SSO rules.

APPENDIX: THE ECONOMICS OF OPPORTUNISM

A. BASIC ECONOMIC MODEL

Consider a single user choosing between Technology 1 and Technology 2 to adopt and incorporate into its new products. If the user selects Technology 1, it will receive benefits of B_1 and incur costs of C_1 , before accounting for any royalty costs. Likewise, if it selects Technology 2, it will receive benefits of B_2 and incur costs of C_2 . We denote the inherent net value of Technology 1 by $N_1 \equiv B_1 - C_1$, and likewise for $N_2 \equiv B_2 - C_2$. We define the *ex ante* “inherent advantage” of Technology 1 over Technology 2 as the additional inherent net value to the user from adopting Technology 1 rather than Technology 2, if both technologies were available royalty-free, i.e., as $V_A \equiv N_1 - N_2$. We label the two technologies so that Technology 1 has a non-negative inherent advantage over Technology 2, i.e., $V_A \geq 0$.

1. *Ex Ante Technology Competition*

We are interested in situations where one or both of these technologies may prove to be patented by a company other than the user, and royalties may be demanded. Denote by R_{1A} the royalties charged on Technology 1 and likewise for R_{2A} . If a technology is not patented (or otherwise covered by intellectual property), its level of royalties must be zero. The two technologies compete as the sellers in a technology market in which the user is a buyer.

(a) The Superior Technology Is Not Patented

If Technology 1 is unpatented, then $R_{1A} = 0$ and the user selects Technology 1. If Technology 2 is patented, there is no positive (profitable) royalty that Patentee 2 can offer that the user will find attractive. Patentee 2 earns nothing, because its technology is inferior.²¹⁰

(b) Only the Superior Technology Is Patented

Since Technology 2 is unpatented, $R_{2A} = 0$. If Patentee 1 charges R_{1A} for Technology 1, the user will find Technology 1 at least as attractive as Technology 2 if and only if $N_1 - R_{1A} \geq N_2$, which can be written as $V_A \geq$

²¹⁰This stark result arises because there is only one user, which does not benefit from developing a second source or otherwise diversifying purchases, i.e., the user simply adopts one technology or the other. This is a reasonable way to model standard setting. Outside the standard-setting context users frequently differ in their needs, and patent holders earn returns from customers that adopt their patented technologies, with multiple patent owners commonly earning positive returns.

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R_{iA} . Therefore, the maximum amount the user would pay in royalties for Technology 1 is given by V_A .

On the other hand, assuming that Patentee 1 incurs no costs from licensing, the smallest royalties that Patentee 1 would accept are zero.²¹¹ Therefore, the mutual gains from trade for the user and Patentee 1 from the user adopting Technology 1 are equal to V_A .

We assume that bargaining is efficient in the sense that Patentee 1 and the user manage to exploit their mutual gains to trade, so the user does indeed adopt Technology 1. (We do so because this is the likely outcome of well-informed bargaining, not because we are imposing full efficiency as a benchmark.) The actual royalties paid depend upon the outcome of negotiations between the user and Patentee 1. As just noted, the negotiation range is $0 \leq R_{iA} \leq V_A$; in the text, the equilibrium R_{iA} is denoted MP_A .

We can define Patentee 1's bargaining skill, β , as the fraction of the gains from trade that Patentee 1 captures in negotiations with the user. In what follows, we generally take β as a fixed parameter between zero and one; thus, the negotiated royalty rate is $R_{iA} = \beta V_A$. For future use, we note that the user's payoff U_A is equal to $N_1 - R_{iA}$ which equals $N_2 + (1 - \beta) V_A$. In words, the user receives the payoff it could get by adopting the inferior technology royalty-free, plus its negotiated share, $1 - \beta$, of Technology 1's inherent advantage.

The value of β can be determined in certain special cases. Most notably, if Patentee 1 can make a single take-it-or-leave-it offer, then Patentee 1 will offer $R_{iA} = V_A$ and the user will accept this offer, so $\beta = 1$.

(c) Both Technologies Are Patented

If both technologies are patented, Patentees 1 and 2 are duopolists in the technology market. The market outcome depends upon the nature of competition between them.

In general, we suppose that the user negotiates with Patentees 1 and 2 to obtain the best terms it can. Efficient bargaining again implies that, in the end, the user will in fact adopt the superior Technology 1. The

²¹¹ The analysis is more complex if Patentee 1 also competes with the user, in which case the patent holder's downstream profits typically fall if the user adopts the superior Technology 1. In such cases, the smallest royalties that Patentee 1 would accept are strictly positive. Additional complexities arise if Patentee 1 is also licensing to the user's rivals. We do not explore those issues here. Farrell & Shapiro, *supra* note 54, develop a model of licensing by a single patent holder to a number of downstream rivals, but they do not study opportunism in that model.

gains from trade between the user and Patentee 1 again are V_A , assuming that the user's alternative to the deal with Patentee 1 is to get a royalty-free license to Technology 2, as is plausible since otherwise Technology 2 is out in the cold. If they split these gains based on their bilateral bargaining power, the royalties paid to Patentee 1 are $R_{IA} = \beta V_A$, just as when Technology 2 is unpatented. Again, we treat βV_A as a benchmark when considering the reward to Patentee 1. Patentee 2 earns nothing since its technology is inferior. As in the case where Technology 2 is not patented, the user's payoff equals $U_A = N_2 + (1 - \beta) V_A$.

The value of β can again be determined in certain special cases. In particular, suppose that Patentee 1 and Patentee 2 compete as Bertrand duopolists in the technology market, by making simultaneous royalty offers. The Bertrand equilibrium is $R_{2A} = 0$ and $R_{1A} = V_A$. Patentee 1 captures all the additional value of its technology (because it can make a single, take-it-or-leave-it offer and, thus, has strong bargaining power), i.e., $\beta = 1$. Other models of duopoly competition between the two patent holders could lead to a different value of R_{1A} , but generally we would expect the user to adopt the superior technology, at least if the user is making an all-or-nothing decision rather than engaging in dual sourcing of technologies.

2. Opportunism and Ex Post Market Power

Now consider how competition in the technology market is altered if the user has already invested resources to use one of the technologies before negotiating. (Opportunism cannot arise for an unpatented technology.)

(a) The User Has Invested in the Superior Technology

Suppose that, prior to negotiating over royalties, the user has made an investment that increases by K_1 the forward-looking value of adopting Technology 1, relative to its effect on the forward-looking value of adopting Technology 2. A simple example would be that the user spends *ex ante* a portion K_1 of the cost C_1 of using Technology 1, in a way that is specific to that technology and has no value if Technology 2 is later adopted instead. We focus on this special case below, although in general K_1 will presumably exceed the user's historical expenditure, since the user found it optimal to make the expenditure earlier rather than later.

These specific investments can take various forms, including: investment in equipment tailored to Technology 1 (Unocal); design of products incorporating Technology 1 (Rambus); learning by doing; or

investment in complementary products designed to work with products incorporating Technology 1. We discuss below and in the text how to measure K_i in theory and in practice.

If the user adopts Technology 1 and pays royalties R_{1P} , then the user's ultimate payoff (consistently evaluated before spending K_i) is $N_i - R_{1P}$, just as earlier. However, if the user shifts gears and subsequently adopts Technology 2 and pays royalties R_{2P} , then the user's ultimate payoff is $N_2 - R_{2P} - K_i$, because the specific investment of K_i ends up being wasted.

In negotiations after the specific investment of K_i , the efficient outcome is for the user to adopt Technology 1, since this technology was inherently superior even before the user made a specific investment in it. At this stage the combined gains to trade available to the user and Patentee 1 from the user adopting Technology 1 are equal to the difference between their combined payoff from adopting Technology 1, which equals N_i , and the combined payoff to the user and Patentee 2 if the user adopts Technology 2, which equals $N_2 - K_i$.²¹² Therefore, these combined gains from trade are $N_i - (N_2 - K_i)$, which equals $V_P \equiv V_A + K_i$.

The bargaining outcome is for Patentee 1 to receive a payoff equal to its disagreement payoff, which is zero, plus its negotiated share, β , of these combined gains from trade. Therefore, the bargaining outcome entails the user adopting Technology 1 and paying royalties to Patentee 1 equal to $R_{1P} = \beta V_P = \beta(V_A + K_i)$. These royalties exceed the benchmark of βV_A calculated above. The difference between the ex post royalties and the ex ante royalties reflects the hold-up power wielded by Patentee 1 as a result of the user's specific investment in Technology 1. The gap ("overcharge") between the ex post royalties and the ex ante royalties for Technology 1 equals $R_{1P} - R_{1A} = \beta(V_P - V_A) = \beta K_i$.

The inherent advantage of Technology 1 does not appear in this expression for the overcharge, which depends only on Patentee 1's bargaining power and the value of the specific investment.

This overcharge reflects the additional power that Patentee 1 can gain from opportunism, as distinct from the competitive advantage or efficiency rent that Patentee 1 enjoys by virtue of its technology's inherent superiority. Since there is no change in total surplus, the overcharge comes at the expense of the user, whose payoff equals $N_i - R_{1P}$, which can be written as $U_P = U_A - \beta K_i$, i.e., the user's ex ante payoff less the

²¹²We are assuming at this point that the user can still adopt Technology 2 without royalties or additional delay. Below, we show how the ex post power achieved by Patentee 1 is even larger in the presence of such delays.

overcharge. Measured as a fraction of the competitive royalties, the overcharge equals

$$\frac{R_{IP} - R_{IA}}{R_{IA}} = \frac{\beta K_1}{\beta V_A} = \frac{K_1}{V_A}.$$

Alternatively, measured as a fraction of the royalties negotiated ex post, the overcharge equals

$$\frac{R_{IP} - R_{IA}}{R_{IP}} = \frac{\beta K_1}{\beta V_P} = \frac{K_1}{V_P},$$

Note that Patentee 1's bargaining power, β , drops out of these expressions. In practice, it may be possible to estimate these ratios by observing the specific investment, K_1 and estimating the inherent advantage V_A or the ex post advantage (switching costs) V_P .

(b) The User Has Invested in the Inferior Technology

Typically the user would make investments in the superior technology, as above. For completeness, we also address the case in which the user negotiates after making investments K_2 specific to the inferior Technology 2.

If the user continues ahead and adopts Technology 2, the combined payoff to the user and Patentee 2 equals V_2 , just as earlier. However, if the user shifts gears and adopts Technology 1, then the combined payoff to the user and Patentee 1 equals $N_1 - K_2$, because the specific investment of K_2 ends up being wasted. The ex post efficient outcome is for the user to adopt Technology 1 if and only if $N_1 - K_2 \geq N_2$, which is equivalent to $V_A \geq K_2$. The analysis, thus, breaks into two sub-cases, depending upon whether or not this inequality is satisfied.

If $V_A \geq K_2$, then it is efficient ex post for the user to adopt Technology 1, notwithstanding the specific investment already made in Technology 2. The ex post gains from trade between the user and Patentee 1 are $N_1 - K_2$. Patentee 1 receives its share of these gains from trade as royalties, so $R_{IP} = \beta(V_A - K_2)$. The user's payoff is $N_1 - R_{IP} - K_2$, which equals $U_{IA} - (1 - \beta)K_2$. Note that both the user and Patentee 1 are worse off as a result of the wasted investment in Technology 2 (and Patentee 2 gains nothing from this investment, either). Collectively, they must pay for the inefficiency associated with this stranded investment; they split the cost according to their bargaining power.²¹³

²¹³ In some settings, the user may make investments in Technology 2 in order to improve its bargaining power vis-à-vis Technology 1. While such investments are socially ineffi-

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Alternatively, if $V_A < K_2$, then it is efficient ex post for the user to adopt Technology 2, despite its inherent inferiority, because of the specific investment already made in it. Effectively, Technology 2 has an ex post advantage of $E_2 = K_2 - V_A$, which is split with the user. Assuming that Patentee 2 has bargaining power β , the resulting royalties are $R_{2P} = \beta E_2$ and the payoff to the user is $U_{2P} = N_2 - R_{2P}$. The user is disadvantaged by having made the specific investment prior to negotiations: the user's payoff is less than N_2 , which is less in turn than the user's payoff from ex ante negotiations, namely $U_{1A} = N_2 + (1 - \beta) V_A$. The cost to the user of prematurely making the specific investment is $U_{1A} - U_{2P} = [N_2 + (1 - \beta) V_A] - [N_2 - \beta(K_2 - V_A)] = (1 - \beta) V_A + \beta(K_2 - V_A)$. In words, the user loses its share of the inherent advantage of Technology 1 (which is never captured, since the user adopts Technology 2) plus the share of Patentee 2's ex post advantage that Patentee 2 captures in the negotiations.

Summarizing, in this sub-case the effect of the user's specific investment in the inferior technology is to eliminate the (benchmark) return of βV_A to Patentee 1, to reduce the payoff to the user by $(1 - \beta) V_A + \beta(K_2 - V_A)$, and to give a windfall return of $\beta(K_2 - V_A)$ to Patentee 2. The aggregate effect is that society forgoes V_A , the inherent advantage of Technology 1.

3. Delay and Loss of Option Value

We now show how this analysis changes if the user would incur delay in adopting Technology 2 after it has already invested in Technology 1.²¹⁴ While there are many ways to model such delay, we simply suppose that the net value of adopting Technology 2 is reduced by being multiplied by $\delta < 1$ if Technology 2 is adopted after the user invests in Technology 1 and subsequently learns that Patentee 1 is demanding royalties.²¹⁵

The result is that the ex post negotiations between the user and Patentee 1 are tilted more in favor of Patentee 1. If the user continues

ficient, they arise in various situations and are akin to dual sourcing strategies adopted by buyers to improve their leverage with suppliers.

²¹⁴ We only present this analysis in the leading case where the user has invested in the superior technology.

²¹⁵ This is the simplest way of modeling delay. For example, if launching a new product using Technology 2 would be delayed by an extra year because the user had been making plans to use Technology 1, then $\delta = 1/(1+r)$, where r is the applicable annual interest rate. The discount factor δ is reduced below the level that simply reflects the time value of money if the user has made additional investments that are not specific to Technology 1, since these investments will have been incurred earlier than would otherwise be optimal given the delay in product introduction.

ahead and adopts Technology 1 and pays royalties R_{1P} , then the user's ultimate payoff is $N_1 - R_{1P}$, just as earlier. However, if the user shifts gears, adopts Technology 2, and pays royalties R_{2P} , then the user's ultimate payoff is $\delta N_2 - R_{2P} - K_1$, because the specific investment of K_1 ends up being wasted and the benefits of adopting Technology 2 are delayed.

Following the analysis above, if Patentee 2 offers $R_{2P} = 0$, then the gains from trade between the user and Patentee 1 are equal to $N_1 - (\delta N_2 - K_1) = N_1 - N_2 + (1 - \delta)N_2 + K_1 = V_A + K_1 + (1 - \delta)N_2$. As usual, Patentee 1 captures its share, β , of these gains from trade, so we get $R_{1P} = \beta[V_A + K_1] + \beta(1 - \delta)N_2$.

The first term here is the ex post royalty calculated above, without any reduction in the value of adopted Technology 2 due to delay. The second term here represents the additional hold-up power of Patentee 1 due to delay in adopting Technology 2 ex post. With such delay, Patentee 1 receives even higher royalties, reflecting the partial loss of benefits from belated adoption of Technology 2. If switching gears and adopting Technology 2 is no longer commercially attractive, due to the delay (perhaps because the market window for Technology 2 has closed), then $\delta = 0$ and Patentee 1's excess payoff grows by Patentee 1's bargaining power, β , times the entire net value previously associated with Technology 2, N_2 . This can be far larger than the benchmark payoff to Technology 1, which is based on $V_A = N_1 - N_2$.

B. UNCERTAINTY

This basic model can easily be further extended to account for uncertainty at the ex ante stage that is resolved by the time ex post negotiations occur. There may be uncertainty about the benefits or costs of either or both of the two technologies. For example, the manufacturing costs associated with the two technologies may be unknown initially but largely known later.

The key observation is that none of the analysis just presented changes at all if one simply reinterprets all the variables as ex ante expected values, at least in the case where Technology 1 will retain an advantage ex post. The key point is that the *expected* overcharge captured by Patentee 1 if the user makes a specific investment of K_1 in Technology 1 prior to negotiating royalties with Patentee 1 is equal to Patentee 1's bargaining power, β , multiplied by the magnitude of that specific investment.

The *actual* overcharge realized by Patentee 1 can be larger or smaller than this amount, depending upon other unexpected developments. In particular, suppose that the ex post realized inherent advantage of

Technology 1 is $\bar{V}_A = V_A + S$, where S reflects a "surprise" element of advantage for Technology 1; by definition, the expected value of S equals zero. A positive value for S corresponds to unexpected good news about Technology 1's relative performance; a negative value for S corresponds to unexpected bad news about that relative performance. The ex post gains from trade from adopting Technology 1 equal $V_A + S + K_1 > 0$, which we assume are positive. Patentee 1 captures a share β of these gains in the form of royalties. Therefore, the royalties equal $\bar{R}_{IP} = \beta(V_A + S + K_1)$, which equals the benchmark level of royalties, βV_A plus a term reflecting the surprise advantage (or disadvantage) of Technology 1, namely βS , plus another term reflecting opportunism, namely βK_1 . The *expected* level of S is zero, but that is not true of the opportunism term.

In this simple model, there is no interaction between the overcharge analyzed above, βK_1 , and the surprise term, βS . While the surprise term, when positive, raises the ex post power of Patentee 1 to charge this user royalties, it simply reflects the unexpectedly large ex post inherent advantage of Technology 1, and is separate from Patentee 1's ability to obtain an overcharge by virtue of the user's specific investment in Technology 1.

To illustrate, suppose that the inherent advantage of Technology 1 is $V_A = \$100$ million, the user makes a specific investment of $K_1 = \$60$ million in Technology 1, and Patentee 1's bargaining power is $\beta = 1/2$. The expected overcharge associated with opportunism is $\beta K_1 = \$30$ million. Now suppose that Technology 1 proves to be even better (relative to Technology 2) than expected, so its realized inherent advantage is $\bar{V}_A = \$120$ million, including the (positive) surprise component of $S = \$20$ million. The ex post realized royalties are $\bar{R}_{IP} = \beta(\bar{V}_A + S + K_1) = 0.5(\$100 + \$20 + \$60) = \$90$ million. Of this, \$50 million reflects the ex ante benchmark level, \$10 million reflects Patentee 1's share of the unexpected (relative) value of Technology 1, and \$30 million reflects opportunism. This \$30 million figure is unaffected by the fact that Technology 1 proved more attractive than was expected. Similarly, if Technology 1 proved (relatively) less attractive than expected, that would not alter the \$30 million opportunism figure. For example, suppose that Technology 1's realized inherent advantage was only $\bar{V}_A = \$80$ million, including a (negative) surprise component of $S = -\$20$ million. Then the ex post realized royalties would be only $\bar{R}_{IP} = \beta(\bar{V}_A + S + K_1) = 0.5(\$100 - \$20 + \$60) = \$70$ million, but Patentee 1 would still capture an extra \$30 million based on opportunism. Extending this point, suppose that Technology 1 turned out to be not much better than Technology 2, due to a (negative) surprise component of $S_1 = -\$60$ million. Then the ex post realized royalties would be only \$50 million, precisely the ex ante bench-

mark level. But it would be an error to conclude that Patentee 1 does not gain from opportunism. Rather, in this numerical example Patentee 1's assumed opportunism just offsets the negative surprise facing Technology 1. Without opportunism, Patentee 1 would only earn *ex post* royalties of \$20 million.

This approach can quite generally accommodate uncertainty about how attractive Technology 1 will be relative to Technology 2. However, this framework assumes well-defined and well-known property rights and is not capable of handling uncertainty over patent validity and scope, or uncertainty about whether a technology is secretly covered by a patent.